Universitetet
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FACULTY OF
SCIENCE
AND TECHNOLOGY

FINAL EXAM: MPE 760 Formation Evaluation and Well Testing

DATE: November 29, 2010

DURATION: 4 hours

“TOOLS” ALLOWED: Standard simple calculator (HP30S, Casio FX-82 or TI-30)

THE SET CONSISTS OF: 3 problems on 9 pages (total)

Problem 1

A 30 days (720 hours) flow test (drawdown) was performed on a fractured new oil well at a rate of 300 STB/D to determine fracture and flow properties and verify the presence of a nearby sealing fault. Use the input parameters in Table 1, the reduced set of pressure data in Table 2, and the plots on the last three pages to answer the questions and carry out the analyses below.

a) Fig. 1 shows a loglog plot of the drawdown data. What flow regimes can be identified in the data considering the assumption that the well is located close to a sealing boundary? Indicate the range of the flow regimes you can identify (time at start and end of each).

b) Fig. 2 shows a semilog plot of the drawdown data with log(Δt) on the horizontal axis. Use representative data points from Table 2 and information from the preceding point to determine the flow capacity kh and permeability k.

c) Fig. 3 shows a square-root-of-time plot of an early part of the drawdown data. Use representative data points from Table 2 and information from the preceding points to determine the fracture half-length x_f and the initial reservoir pressure p_i.

d) Estimate the distance to the nearby boundary based on the derivative response in Fig. 1. Also estimate how close a second boundary can be located without being observed in the data. Assume that the fracture is parallel to the nearest boundary.

e) If the well had been placed closer to the boundary it might be possible to observe another “standard” flow regime in the data. Describe this possibility.

Table 1 – Input parameters for Problem 1

Formation thickness, h	=	103	ft
Porosity, ϕ	=	0.09	
Viscosity, μ	=	1.8	cp
Total compressibility, c_t	=	$1.7\text{x}10^{-5}$	psi^{-1}
Volume factor, B	=	1.33	RB/STB
Wellbore radius, r_w	=	0.354	ft

Table 2 – Pressure data for Problem 1

Time (hrs)	Pressure (psia)	Time (hrs)	Pressure (psia)
0.0029	6499.05	191.08	6189.83
0.0086	6498.36	216.08	6174.68
0.0144	6497.88	241.08	6161.02
0.0230	6497.32	266.08	6148.60
0.0326	6496.81	291.08	6137.22
0.0517	6495.98	316.08	6126.71
0.0820	6494.94	341.08	6116.95
0.1299	6493.63	366.08	6107.84
0.2310	6491.50	391.08	6099.30
0.4108	6488.67	416.08	6091.26
0.7305	6484.89	441.08	6083.67
1.2991	6479.85	466.08	6076.48
2.3101	6473.12	491.08	6069.64
4.1080	6463.93	516.08	6063.13
7.3052	6450.49	541.08	6056.92
12.991	6429.72	566.08	6050.98
23.101	6398.33	591.08	6045.28
41.080	6354.71	616.08	6039.81
66.080	6310.05	641.08	6034.55
91.080	6276.22	666.08	6029.49
116.08	6249.04	686.08	6025.57
141.08	6226.37	706.08	6021.76
166.08	6206.88	720.00	6019.17

Problem 2

Data from a short buildup after a long flow period at 1100 Sm^3/d need to be reevaluated after a production log showed that only 14 m of the formation contributed to the production.

a) Determine new permeability and skin values from the original data listed in Table 3 based on the reduced thickness.

b) If the radius of investigation at the end of the buildup was 720 m, what will it be after the change in thickness?

Table 3 – Formation and well parameters for Problem 2

Formation thickness, h	=	78	m
Permeability, k	=	105	md
Porosity, ϕ	=	0.17	
Viscosity, μ	=	1.12	cp
Total compressibility, c_t	=	$2.1\text{x}10^{-4}$	bar^{-1}
Volume factor, B	=	1.53	Rm^3/Sm^3
Wellbore radius, r_w	=	0.108	m
Skin value, S	=	5.2	

Problem 3

The following data have been taken from a modified isochronal test of a gas well with low static pressure at 1881.1 psia and the last flow period stabilized.

q_{sc} (Mscf/d)	p_{wf} (psia)
12501	1797.0
0	1872.7
16103	1742.2
0	1868.1
19812	1679.5
0	1862.3
22707	1620.1
18200	1611.3

Use the information above to carry out the analyses below.

a) Determine the deliverability and AOF potential of the well by using LIT analysis and direct computations without plotting (assume that the data to be consistent such that computations can be based on any chosen representative data points).

b) Determine the deliverability and AOF potential of the well by using simple loglog analysis (back-pressure equation) and direct computations without plotting (assume the data to be consistent such that computations can be based on any chosen representative data points).

STANDARD EQUATIONS

$$p_D = \frac{kh}{18.66 qB\mu}\Delta p$$ (SI units, oil)

$$p_D = \frac{kh}{141.2 qB\mu}\Delta p$$ (field units, oil)

$$p_D = \frac{p_r kh}{0.06563 q_{sc} Z_r \mu_r T_r}\Delta p$$ (SI units, gas at high pressure)

$$p_D = \frac{p_r kh}{711 q_{sc} Z_r \mu_r T_r}\Delta p$$ (field units, gas at high pressure)

$$t_D = \frac{0.000355 kt}{\phi\mu c_t r_w^2}$$ (SI units, oil and gas)

$$t_D = \frac{0.000264 kt}{\phi\mu c_t r_w^2}$$ (field units, oil and gas)

$$C_D = \frac{C}{2\pi\phi h c_t r_w^2}$$ (SI units, oil and gas)

$$C_D = \frac{5.615 C}{2\pi\phi h c_t r_w^2}$$ (field units, oil and gas)

$$\frac{t_D}{C_D} = \frac{0.002232 kht}{\mu C}$$ (SI units, oil and gas)

$$\frac{t_D}{C_D} = \frac{0.0002951 kht}{\mu C}$$ (field units, oil and gas)

$$C = \frac{qB}{24}\frac{t}{\Delta p} = c_{wb} V_{wb}$$

$$\Delta p = m' t = \frac{qB}{24C} t$$

STANDARD EQUATIONS (Contin.)

$$m = \frac{21.49 q B \mu}{kh}$$ (SI units)

$$m = \frac{162.6 q B \mu}{kh}$$ (field units)

$$S = 1.151\left(\frac{p_i - p_{1hr}}{m} - \log\frac{k}{\phi\mu c_t r_w^2} + 3.098\right)$$ (SI units, drawdown data)*

$$S = 1.151\left(\frac{p_{1hr} - p_{wf,s}}{m} - \log\frac{t}{t+1} - \log\frac{k}{\phi\mu c_t r_w^2} + 3.098\right)$$ (SI units, buildup data)*

*) Field units: replace 3.098 by 3.23.

$$\Delta p_S = \frac{m}{1.151} S$$

$$r_{inv} = 0.0286\sqrt{\frac{kt}{\phi\mu c_t}}$$ (SI units)

$$r_{inv} = 0.0246\sqrt{\frac{kt}{\phi\mu c_t}}$$ (field units)

$$d = 0.01412\sqrt{\frac{kt}{\phi\mu c_t}}$$ (SI units)

$$d = 0.01217\sqrt{\frac{kt}{\phi\mu c_t}}$$ (field units)

$$p_i - \overline{p} = \frac{m}{1.151} 2\pi t_{DA}$$

$$p_{ws}(\Delta t) = \overline{p} \quad \text{when} \quad \Delta t_e = \frac{\phi\mu c_t A}{0.000355 k C_A}$$ (SI units)

$$p_{ws}(\Delta t) = \overline{p} \quad \text{when} \quad \Delta t_e = \frac{\phi\mu c_t A}{0.000264 k C_A}$$ (field units)

STANDARD EQUATIONS (Contin.)

Fractured wells:

$$m' = \frac{0.6236qB}{hx_f}\sqrt{\frac{\mu}{k\phi c_t}}$$ (SI units)

$$m' = \frac{4.064qB}{hx_f}\sqrt{\frac{\mu}{k\phi c_t}}$$ (field units)

$$S = \ln\frac{2r_w}{x_f}$$ (fracture with infinite conductivity)

$$S = \ln\frac{er_w}{x_f} = \ln\frac{2.718r_w}{x_f}$$ (fracture with uniform flux)

Reservoir limit analysis:

$$m' = \frac{0.04167qB}{\phi c_t Ah}$$ (SI units)

$$m' = \frac{0.2339qB}{\phi c_t Ah}$$ (field units)

$$p_0 = p_i - \frac{18.66qB\mu}{kh}\left(\frac{1}{2}\ln\frac{4A}{e^{\gamma}C_A r_w^2} + S\right)$$ (SI units)

$$p_0 = p_i - \frac{141.2qB\mu}{kh}\left(\frac{1}{2}\ln\frac{4A}{e^{\gamma}C_A r_w^2} + S\right)$$ (field units)

$$e^{\gamma} = e^{0.57721..} = 1.781\ldots$$

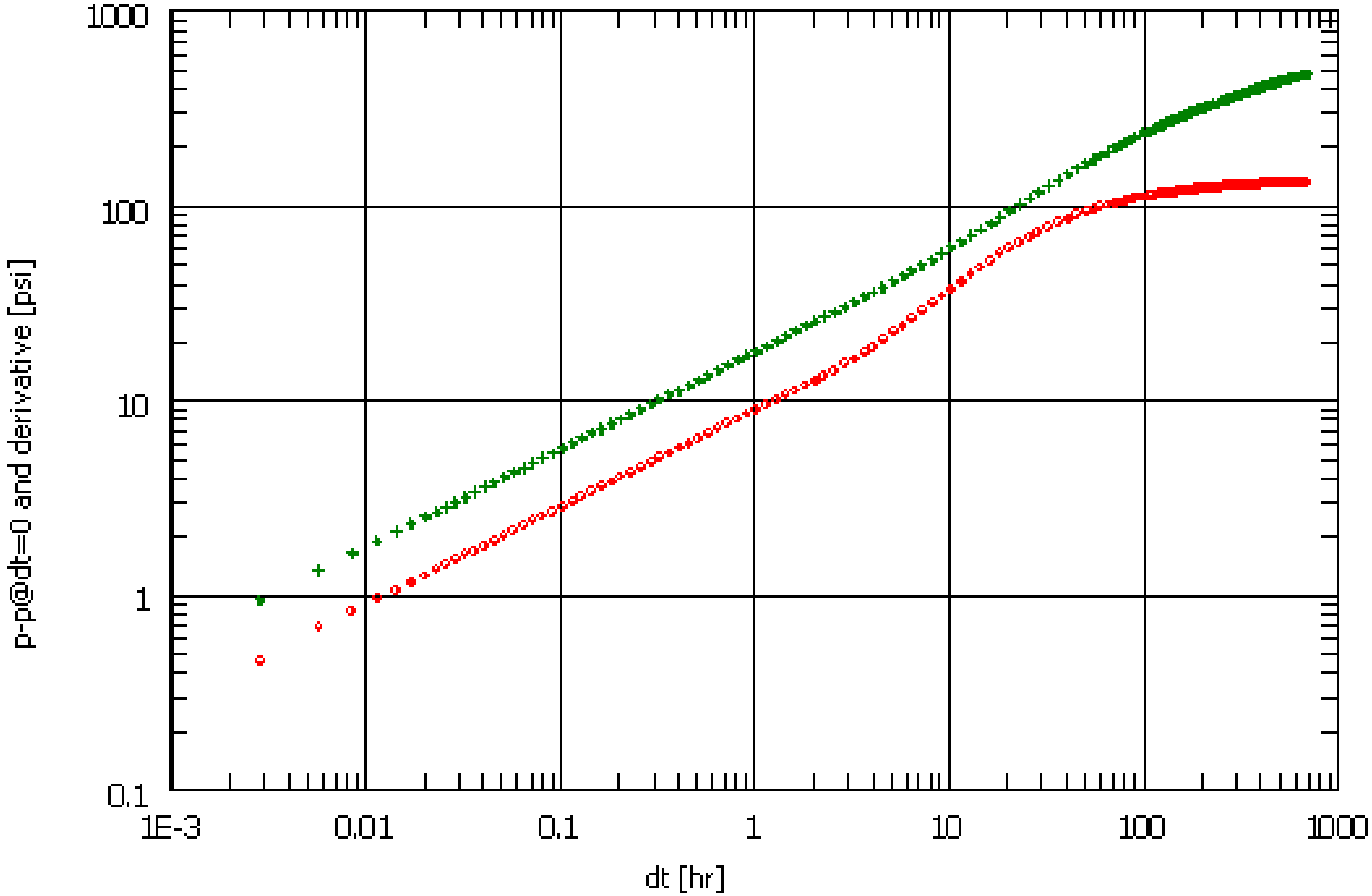
Gas tests:

$$q_{sc} = C(\overline{p}^2 - p_{wf}^2)^n$$ (simplified deliverability, p^2 formulation)

$$\overline{p}^2 - p_{wf}^2 = aq_{sc} + bq_{sc}^2$$ (LIT based deliverability, p^2 formulation)

$$\text{AOF} = \frac{1}{2b}\left(-a + \sqrt{a^2 + 4b\overline{p}^2}\right)$$ (LIT based AOF, p^2 formulation)

Fig. 1



1000
100
10
1
0.1
1E-3
0.01
0.1
1
10
100
1000
p-p@dt=0 and derivative [psi]
dt [hr]

Fig. 2

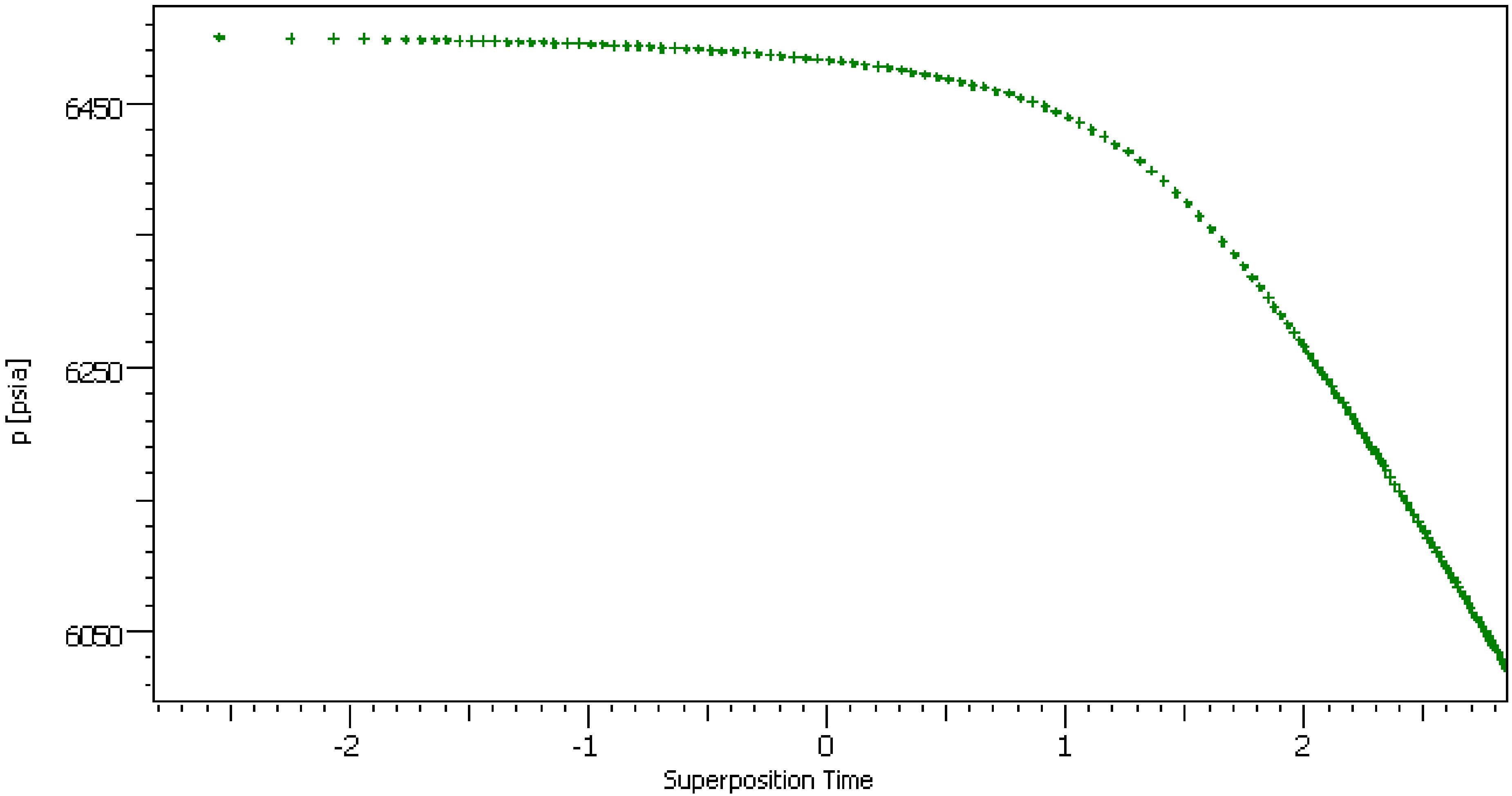


Fig. 3