Universitetet
i Stavanger

FACULTY OF SCIENCE AND TECHNOLOGY

FINAL EXAM: MPE 350 Well Test Analysis

DATE: 18. May, 2009

DURATION: 4 hours

"TOOLS" ALLOWED: Simple, definite calculator (HP30S, Casio FX-82 or TI-30)

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

Problem 1

An oil production well was tested with a 12 hours buildup for diagnostic purposes following 300 days (almost 10 months) of relatively stable production at 5200 STB/d. The main objectives of the test were to determine the current flow capacity and skin along with the reservoir pressure. Use the input parameters in Table 1, the reduced set of buildup data in Table 2, and the plots on the last three pages to answer the questions and carry out the analyses below. Assume that the well is a single producer in a closed bounded drainage area produced under simple depletion.

a) Fig. 1 shows a loglog plot of the buildup data. What flow regimes appear to be evident in the data? For each such flow regime, determine a key model parameter. To this end, select representative data points from Table 2.

b) Fig. 2 shows a Horner plot of the buildup data with $\log((t+\Delta t)/\Delta t)$ on the horizontal axis (data plotted towards the left). By selecting representative data points from Table 2, determine the semilog slope m, p_{1hr}, kh, k, S, Δp_S and p^*.

c) Can p^* from the Horner analysis be used to estimate the current reservoir (average) pressure? Is it possible to estimate the current reservoir pressure without knowing the drainage area?

d) Proceed with data from the Horner plot, and assume that the well is centered in a circular drainage area with outer radius 4100 ft. Use this information to determine the average reservoir pressure at shut-in. Note that C_A = 31.62 for the assumed model. Use available data to also estimate reservoir pressure prior to the listed production?

e) If the drainage area differs from a simple radial model with at least one sealing fault near the well, how close can the fault be located without being seen in the buildup data?

f) The linear plot in Fig. 3 of early data can be used to check consistency of the input data and determine one model parameter. By picking data from Table 2, carry out these analyses.

Table 1 – Input parameters for Problem 1

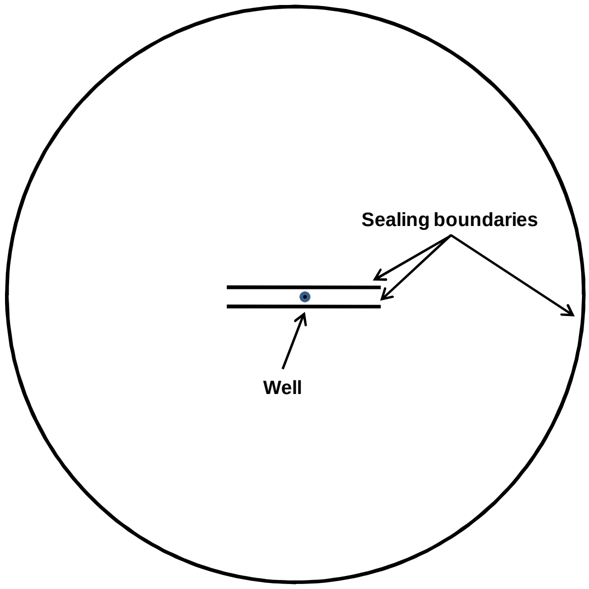
Formation thickness, h	=	95	ft
Porosity, ϕ	=	0.19	
Viscosity, μ	=	0.84	cp
Total compressibility, c_t	=	2.14×10^{-5}	psi^{-1}
Volume factor, B	=	1.45	RB/STB
Wellbore radius, r_w	=	0.354	ft
Pressure at shut-in, $p_{wf,s}$	=	5466.3	psi

Table 2 – Pressure data for Problem 1

Buildup time (hrs)	Pressure (psi)	Buildup time (hrs)	Pressure (psi)
0.0010	5470.5	0.2015	5812.8
0.0020	5474.6	0.2537	5836.7
0.0030	5478.6	0.3193	5856.0
0.0040	5482.6	0.4020	5870.9
0.0060	5490.5	0.5061	5882.1
0.0080	5498.1	0.6372	5890.6
0.0101	5506.0	0.8021	5897.4
0.0127	5515.5	1.0098	5903.2
0.0160	5527.1	1.2713	5908.5
0.0201	5541.1	1.6005	5913.5
0.0254	5557.8	2.0148	5918.3
0.0319	5577.6	2.5365	5923.0
0.0402	5600.5	3.1933	5927.6
0.0506	5626.7	4.0202	5932.1
0.0637	5655.9	5.0611	5936.6
0.0802	5687.4	6.3715	5940.9
0.1010	5720.3	8.0213	5945.2
0.1271	5753.2	10.0982	5949.5
0.1600	5784.6	12.0000	5952.6

Problem 2

Consider a vertical well located in a short open-ended channel inside a circular drainage area as shown in the sketch below.



a) What type of flow regimes can be expected from the well above in a long period with constant rate production?

b) Assuming properties inside the circular drainage area to be homogeneous, make a sketch of loglog derivative data consistent with this type of model under constant rate production.

c) Repeat the last point for buildup data following a long producing period.

Problem 3

The following data have been taken from a flow-after-flow (FAF) test of a gas well with low static pressure 1881 psia.

q_{sc} (MMscf/d)	p_{wf} (psia)
12.5	1797
16.1	1750
19.8	1692
22.7	1639

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 set is 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 back-pressure analysis (loglog) and direct computations without plotting (assume that the data set is 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.)

$$m = \frac{21.49 qB\mu}{kh} \qquad \text{(SI units)}$$

$$m = \frac{162.6 qB\mu}{kh} \qquad \text{(field units)}$$

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

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

*) Field units: replace 3.098 by 3.23.

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

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

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

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

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

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

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

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

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)

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

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)

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

Fig. 1

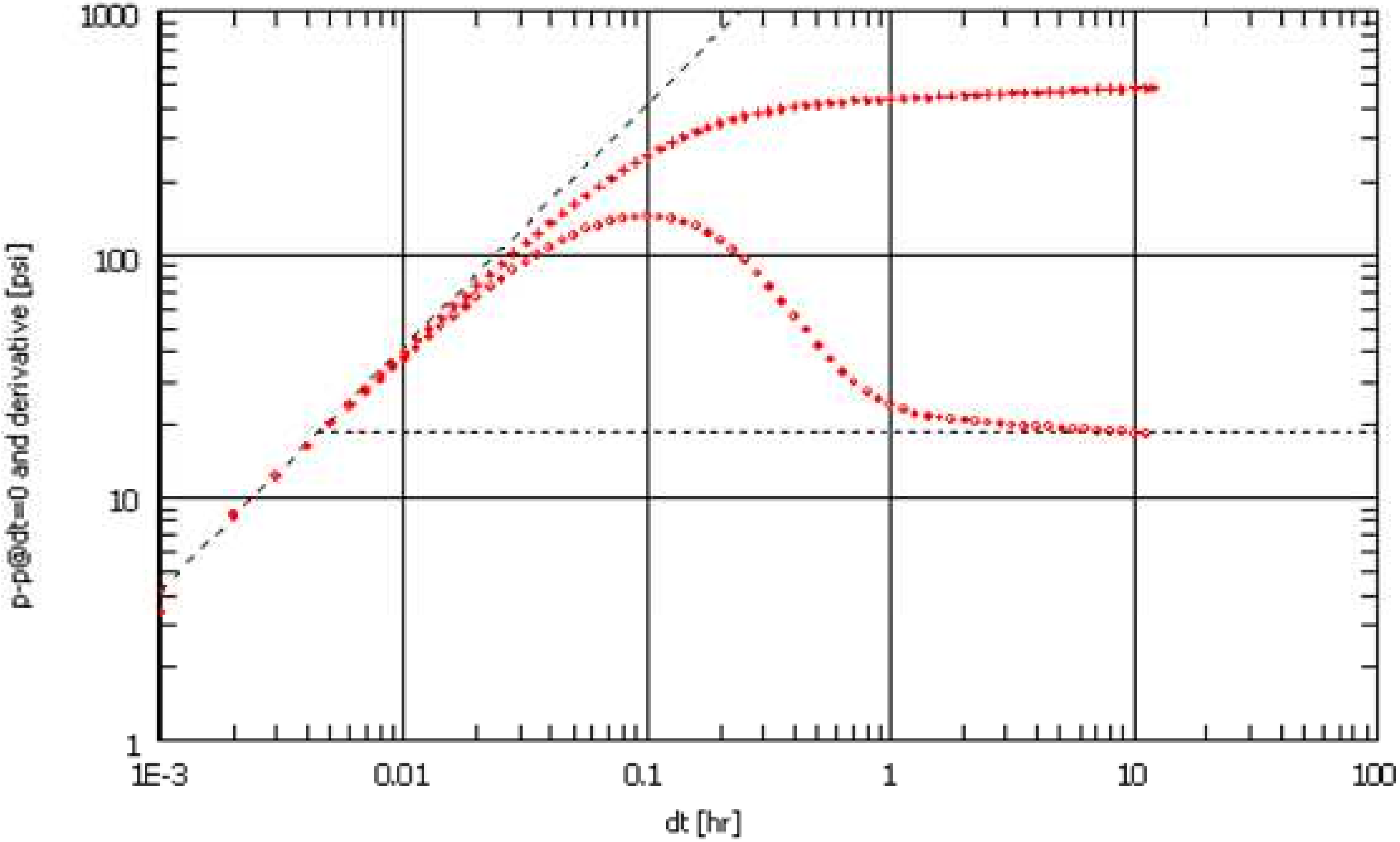


Fig. 2

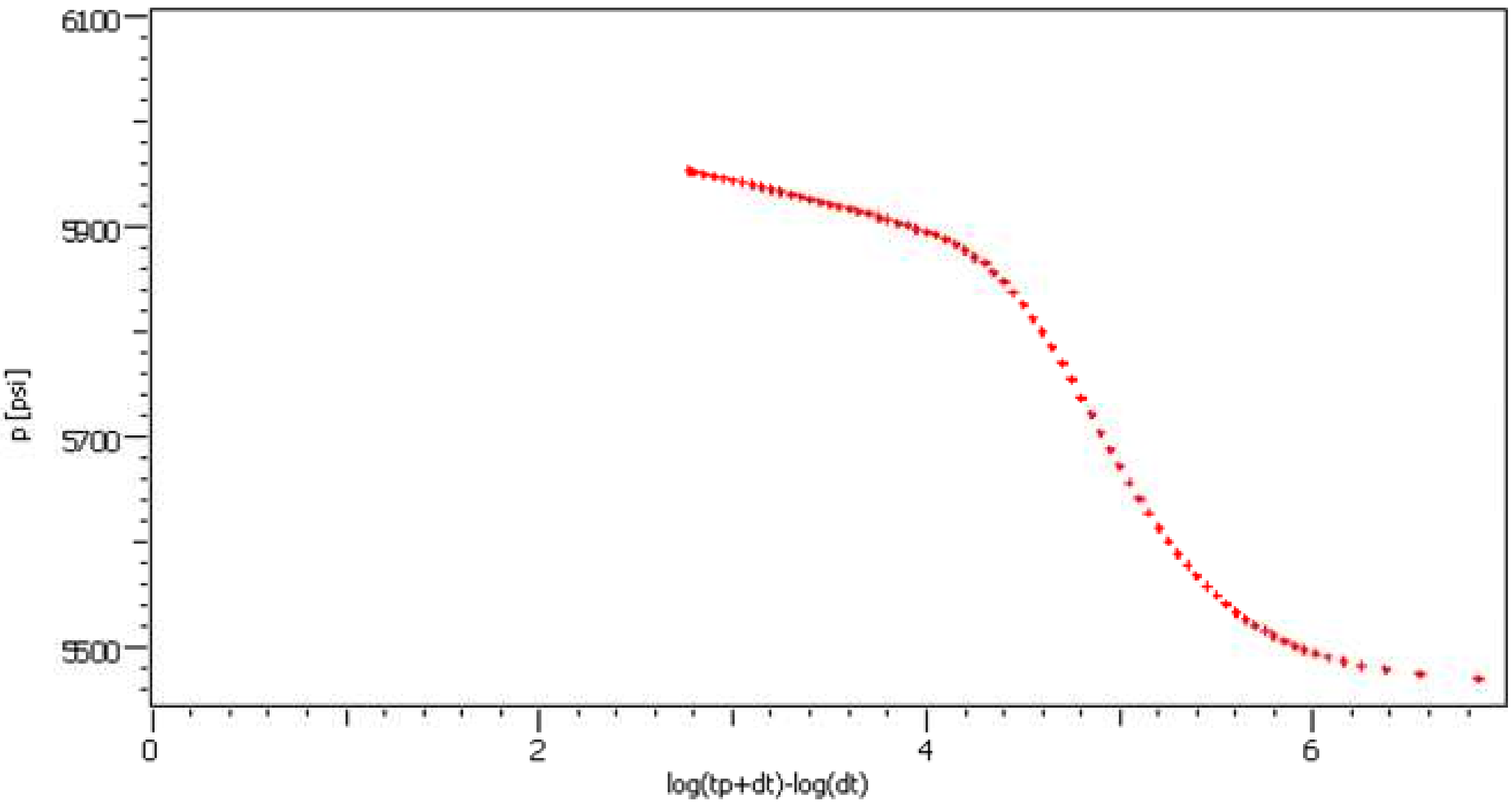
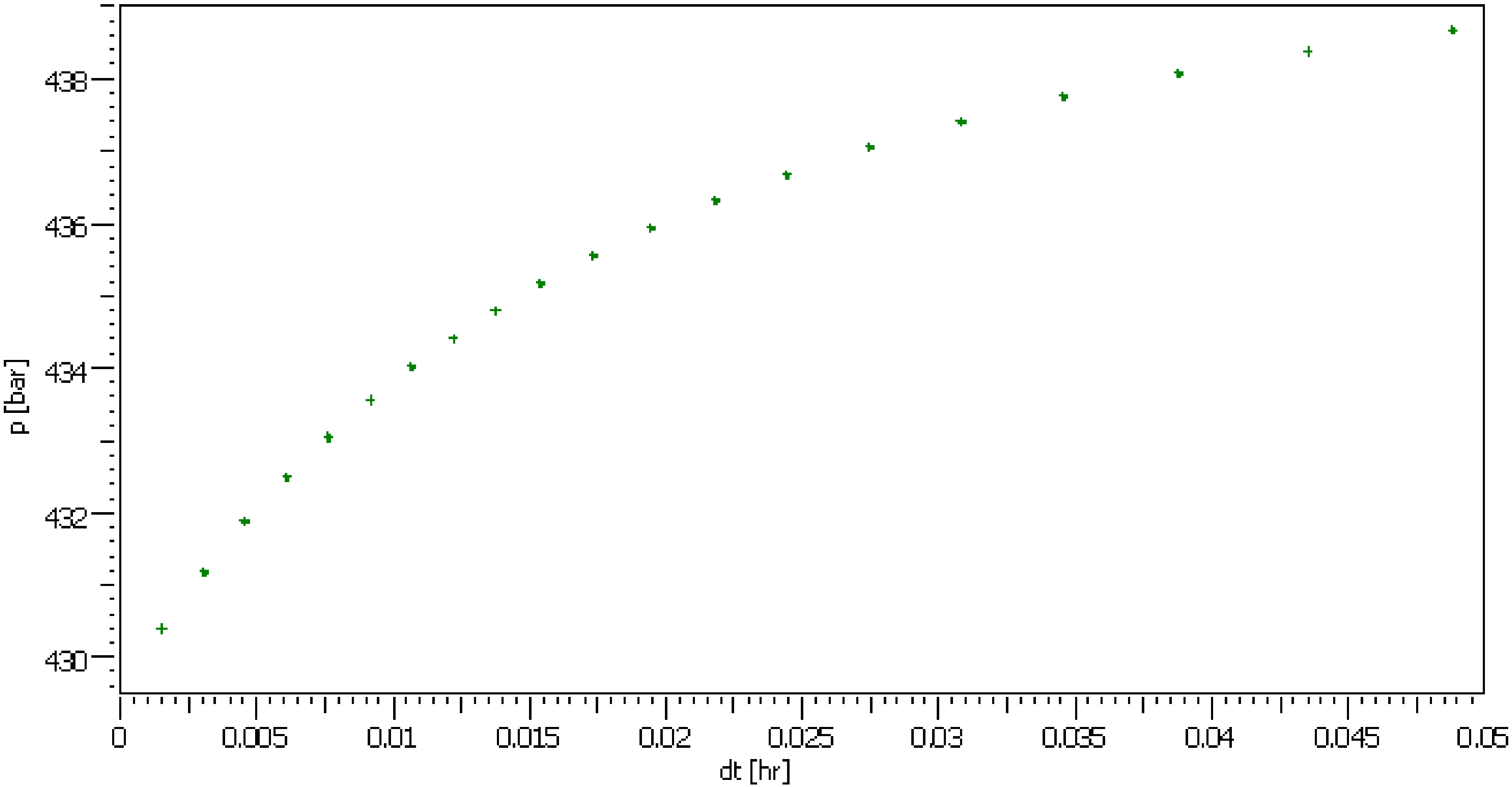


Fig. 3



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