University of Stavanger

FACULTY OF SCIENCE AND TECHNOLOGY

English

SUBJECT: PET 660 Reservoir simulation

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Solution

Problem 1

a) Absolute permeability properties:
   - Heterogeneous
   - Anisotropic
   - Time independent

   Amount of input required: 3*(number of grid blocks)

b) Table data:
   - 1. column: Rs values
   - 2. column: pressure values
   - 3. column: oil volume factor Bo
   - 4. column: oil viscosity
   - In the first 8 rows saturated data are specified, in the last 3 rows under saturated data are specified.

Problem 2

a) Taylor expansion is used to determine the order of an approximation. If the error r can be written as $r = m(z)\Delta x^k$, m a bounded function, the approximation is of order k. Here Δx is the distance between computational points.

See course material for analysis of approximation od u_{xx}.

b) See Example 5.5, course notes on Finite Differences.

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Problem 3

a) In GOC gas and oil pressures are 300 bars. Using

$$p_o = 300 + 0.4 * h, \quad p_g = 300 + 0.05 * h$$

where h is the distance from GOC to the center of a layer, positive for layers below and negative for layers above GOC.
Moreover, p_o is computed in WOC resulting in a reference value for p_w. Water pressure in each layer is computed using the same procedure as for oil and gas pressures.
Result of pressure computations:

Layer	p_o	p_g	p_w
1	292	299	284
2	298	299.75	291.5
3	302		296.5
4	310		306.5
5	320		319
6			336.5

b) Next, compute capillary pressures in each layer.

Finally, saturations are computed:
- Sw = 1 below WOC
- in transition zone above WOC, Sw is determined from Pcow(Sw) = $p_o - p_w$
- above oil/water transition zone Sw = Swr.
- Sg = 0 below GOC
- in transition zone above GOC, Sg is determined from Pcro(Sg) = $p_g - p_o$
- above gas/oil transition zone Sg = 1-Swr

Layer	P_{cow}	S_w	P_{cgo}	S_g
1	8	0.2	7	0.8
2	6.5	0.2	1.75	0.28
3	5.5	0.2		0
4	3.5	0.3		0

5	1	0.8		0
6		1		0

$$S_o = 1 - S_w - S_g$$

Problem 4

a) See course notes on linearization, page 66.

b) Using upstream evaluation

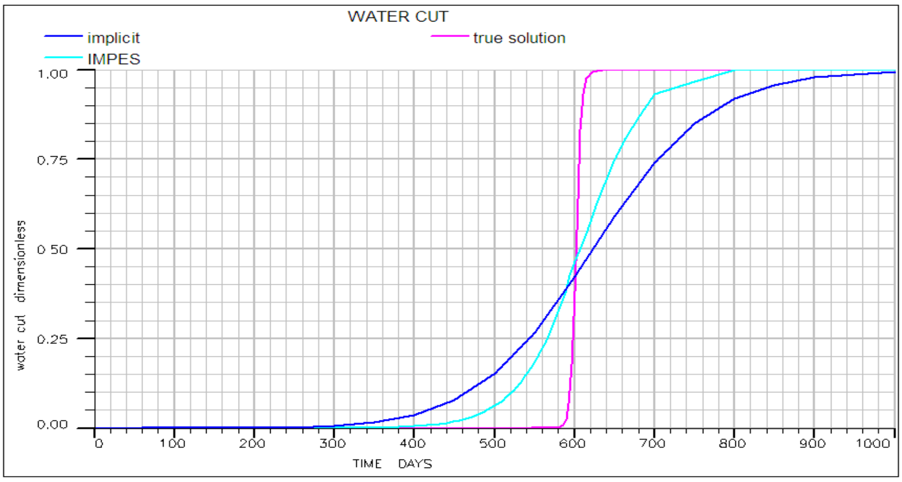
$$F_T = C\left(\frac{k_{ro}(S_{wi+1})}{\mu_o(p_{i+1}, p_{si+1})B_o(p_{i+1}, p_{si+1})}\right)(p_{i+1} - p_i) \ .$$

Linearization of F_T at iteration step k+1:

$$\left(\frac{\partial F_T}{\partial p_{i+1}}\right)^k \Delta p_{i+1}^k + \left(\frac{\partial F_T}{\partial p_i}\right)^k \Delta p_i^k + \left(\frac{\partial F_T}{\partial S_{wi+1}}\right)^k \Delta S_{wi+1}^k + \left(\frac{\partial F_T}{\partial p_{si+1}}\right)^k \Delta p_{si+1}^k + F_T^k \ .$$

Problem 5

a) IMPES solution will produce results closer to the true solution than the implicit method.



IMPES will use shorter time step lengths to ensure stability. Shorter time steps results in smaller time truncation error. Hence, IMPES produces more accurate results than implicit method.

b) Both gas and water coning will occur. The coning shapes will be so narrow that the coarse grid will not be able to model the shapes. Fine grid will model the coning shapes more accurately. Hence, coning will appear sooner for the fine grid resulting in lower recovery.

To reduce coning, use of horizontal wells will be the best option. The draw down will be spread over a longer distance and coning will be reduced.