MUFITS

Reservoir Simulation Software
version 2016.C

Wellbore friction

Author: Andrey Afanasyev

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Moscow, Russia

1 Modelling wellbore friction

1.1. Well models

There are two types of well model in MUFITS [1]. The first option is the Averaged Model. This default well model can be specified by leaving default value for the 12th argument of the WELSPECS keyword (or setting it to AVG). If this model is used, there is no ”grid” resolution along the wellbore. The wellbore consists of a single pipesegment. Thus, the wellbore hydraulics cannot be simulated using the Averaged Model. The parameters of the reservoir fluid are averaged along the wellbore. An example of this type of the well is the INJECTOR on Fig.1.1;

The second option is the Multisegment Model. This model can be specified for a particular well by changing the 12th argument of the WELSPECS keyword to SEG. In this case, the well is resolved into several pipesegments (well segements) connected with pipejunctions (the well PRODUCER on Fig.1.1). The fluid parameters are different in different pipesegments. A new pipesegment is created by MUFITS for any new well completion specified by the COMPDAT keyword. The multisegement well should be built from the stock tank downward. The order of completions specification in the COMPDAT keyword is relevant. The first completion should be the closest to the stock tank (or well pump, see Fig.1.1), and the last completion specified in the COMPDAT keyword should be the farthest one from the stock tank. The pipesegment associated with the first COMPDAT record is used for the bottom-hole parameters calculation.

The flow between the pipesegments (that is along pipejunctions) is calculated by the Haaland's formula. The relative roughness of the wellbore walls for every pipesegment is the 15th argument of the COMPDAT keyword. A more complicated models for wellbore hydraulics (e.g. the drift flux model) or tabulated wellbore flow are not available in the current release.

The multisegment well partition in parallel runs is controlled by the 18th argument of the WELSPECS keyword. If this parameter is T (default option) then all pipesegments associated with the well are assigned to the same node of the computer. If this parameter is F then the pipesegments can be partitioned between the computer nodes.

1.2. Recommendations on using multisegemt wells

Since the timescales for flows in porous medium and for wellbore flows are several order of magnitude different, the simulator can experience poor convergence in some cases if the multisegment wells are involved. Therefore, our recommendations on using this type of wells are as follows

- Do not use multisegment wells unless it is really necessary to take into account wellbore hydraulics. For instance, if the default Averaged Model is used for both wells in the 7th SPE study then the results do not change a lot. Thus, it is not necessary to use the Multisegment Well model in this particular problem;

- In the INIT (or SCHEDULE) section specify initial conditions in the pipesegments associated with the multisegment well. The initial conditions should be as close as possible to the parameters in the wellbore after it is opened. The pipesegments can be referred to by using the FLUXNUM number. The FLUXNUM number associated with the well is the 17th argument of the WELSPECS keyword;

- If the well controls are changed (e.g. well rate is changed) then limit the following time step with a small value (e.g. 0.001 days or less) using the TUNING keyword;
- Decrease the minimal timestep using TUNING keyword;
- Disable the FAST option;
- Increase the ILUTFILL and decrease the ILUTDROP parameters;
- Do not specify the datum depth in the WELSPECS keyword;
- Increase the 25th argument of the TUNING keyword. The default value of this argument is 10. Set it to 25 or 100. Use this option only if all above recommendations do not help.

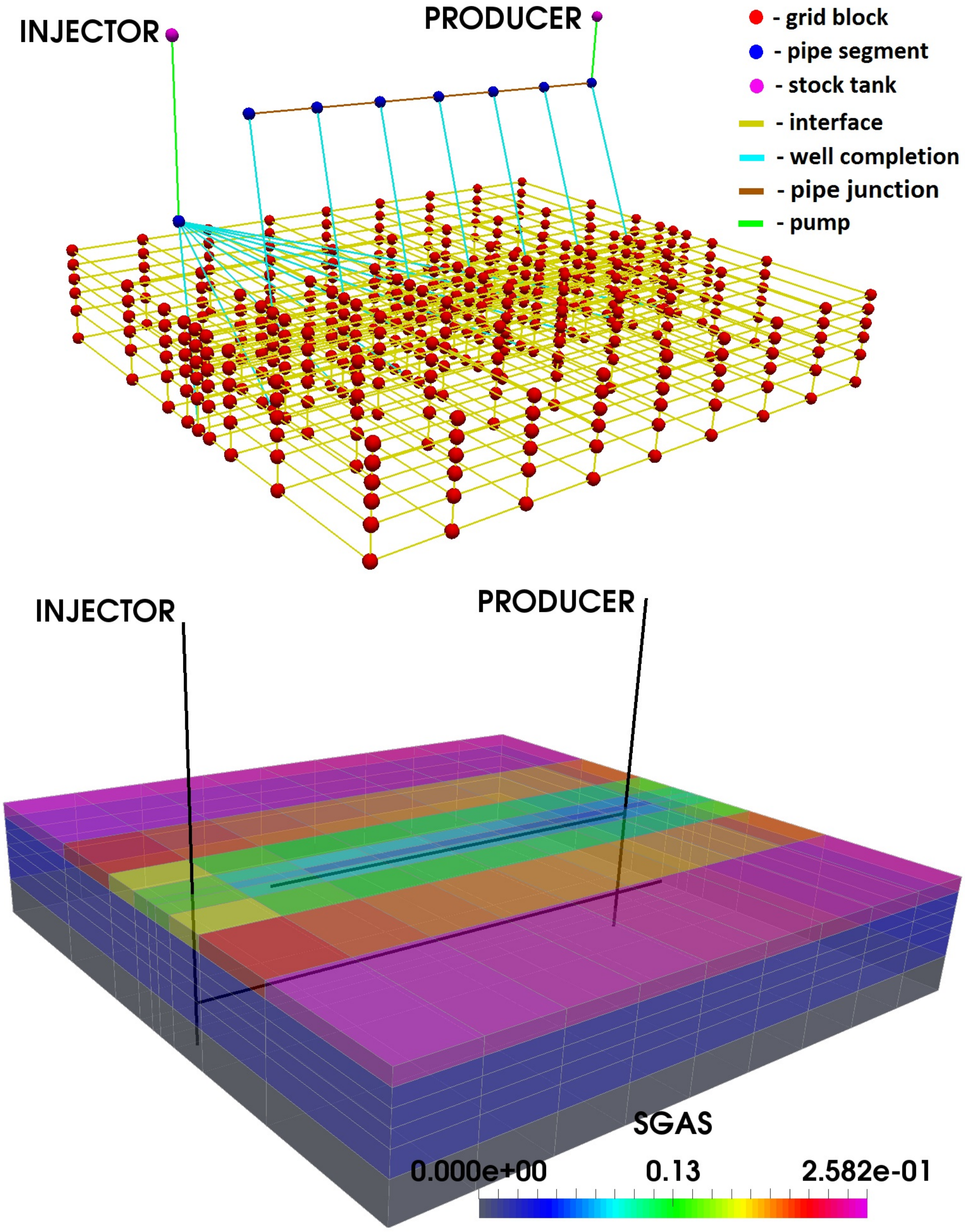

Figure 1.1: Logical (top) [2] and physical (bottom) models of the 7th SPE Comparative Study (case 4b). The pipe segments and stock tanks are shifted in space to make the edges of graph (well completions) visible.

2 Validation against 7th SPE study

Below you can find results of MUFITS validation against the 7th SPE Comparative Study [3]. This benchmark problem concerns oil and gas production from a horizontal well completed just above the water-oil contact. Thus, conning tendencies are important. The pressure drop in the wellbore due to the friction is simulated. The effect of well length and rates on the recovery is examined. The water flow to the horizontal wellbore from the water zone below water-oil contact is simulated with a line source of water. Thus, this case study involves two types of MUFITS wells: both the Averaged Model (for the line source of water; INJECTOR) and the Multisegment Well (for the production well; PRODUCER), see Fig.1.1.

From the physical point of view the wellbore friction is irrelevant in this problem. This can be verified by changing the PRODUCER model to the Averaged Model. The simulation results are much more sensitive to the three-phase oil relative permeability, since the high production rate in cases 3 and 4 results in a large amount of free gas in the near-wellbore zone. We use the 1st Stone's model for the scenarios 1, 2 and 3, and the 2nd Stone's model for the scenario 4. The results of MUFITS simulations vary within the range of results published in [3] depending on the relative permeability model. Nevertheless, the the 7th SPE benchmark demonstrates MUFITS options for modelling well hydraulics.

The background figures below are taken from the 7th SPE study paper [3], whereas the red lines show MUFITS results. The MUFITS results are in good agreement with results of other code.

2.1. Case 3a

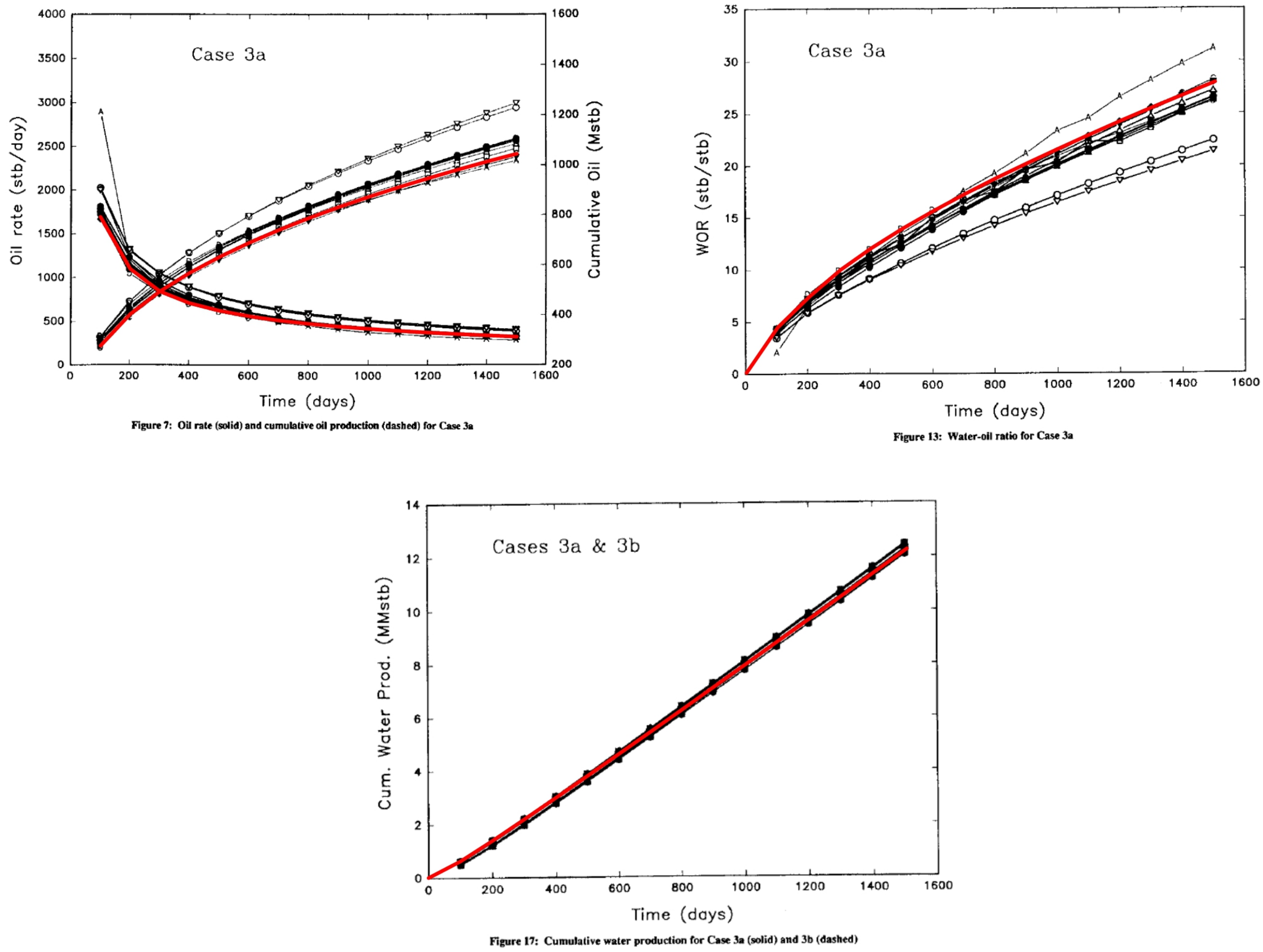

Figure 2.1: Comparison between MUFITS (red curves) and the 7th SPE paper, case 3a (background figures).

2.2. Case 3b

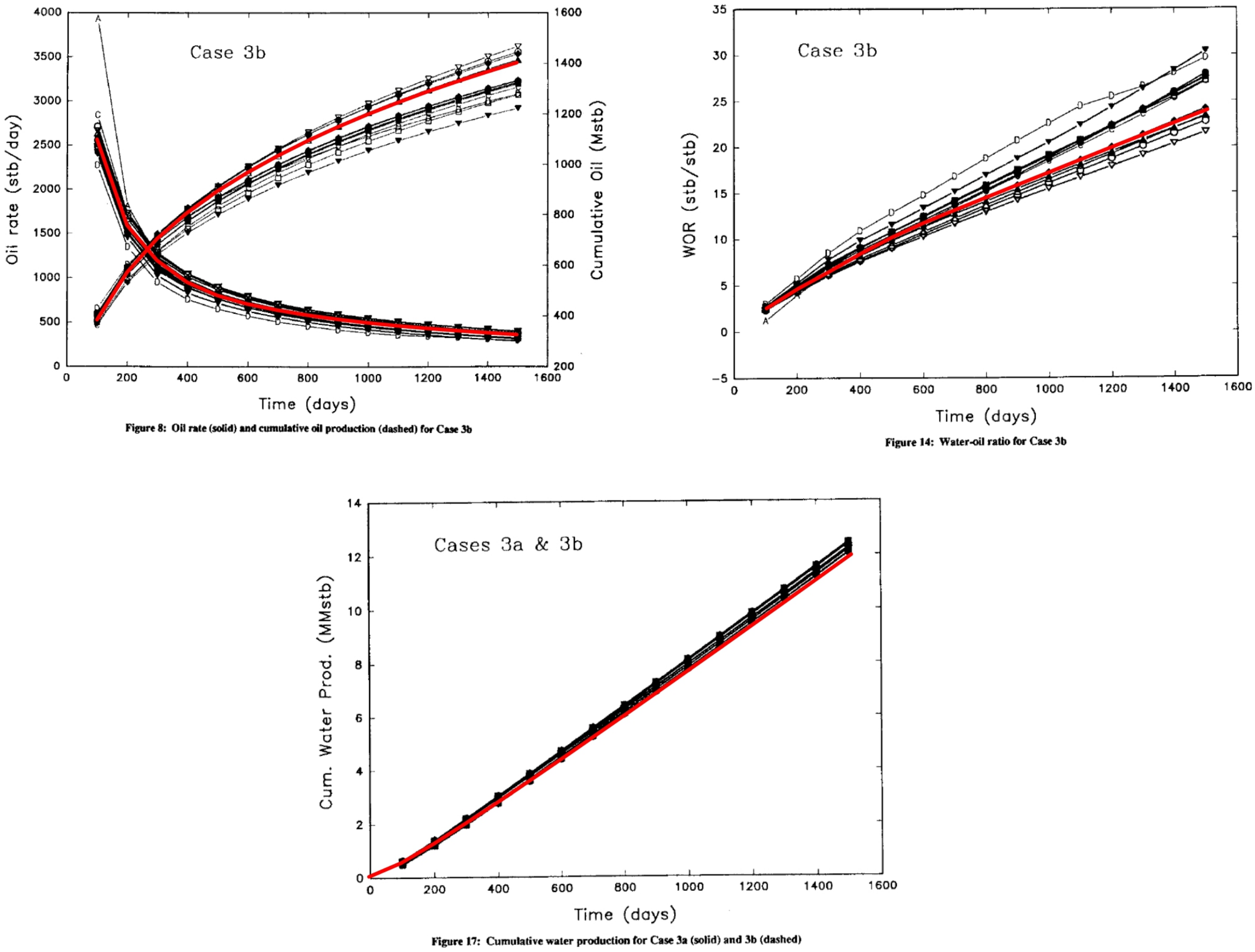

Figure 2.2: Comparison between MUFITS (red curves) and the 7th SPE paper, case 3b (background figures).

2.3. Case 4a

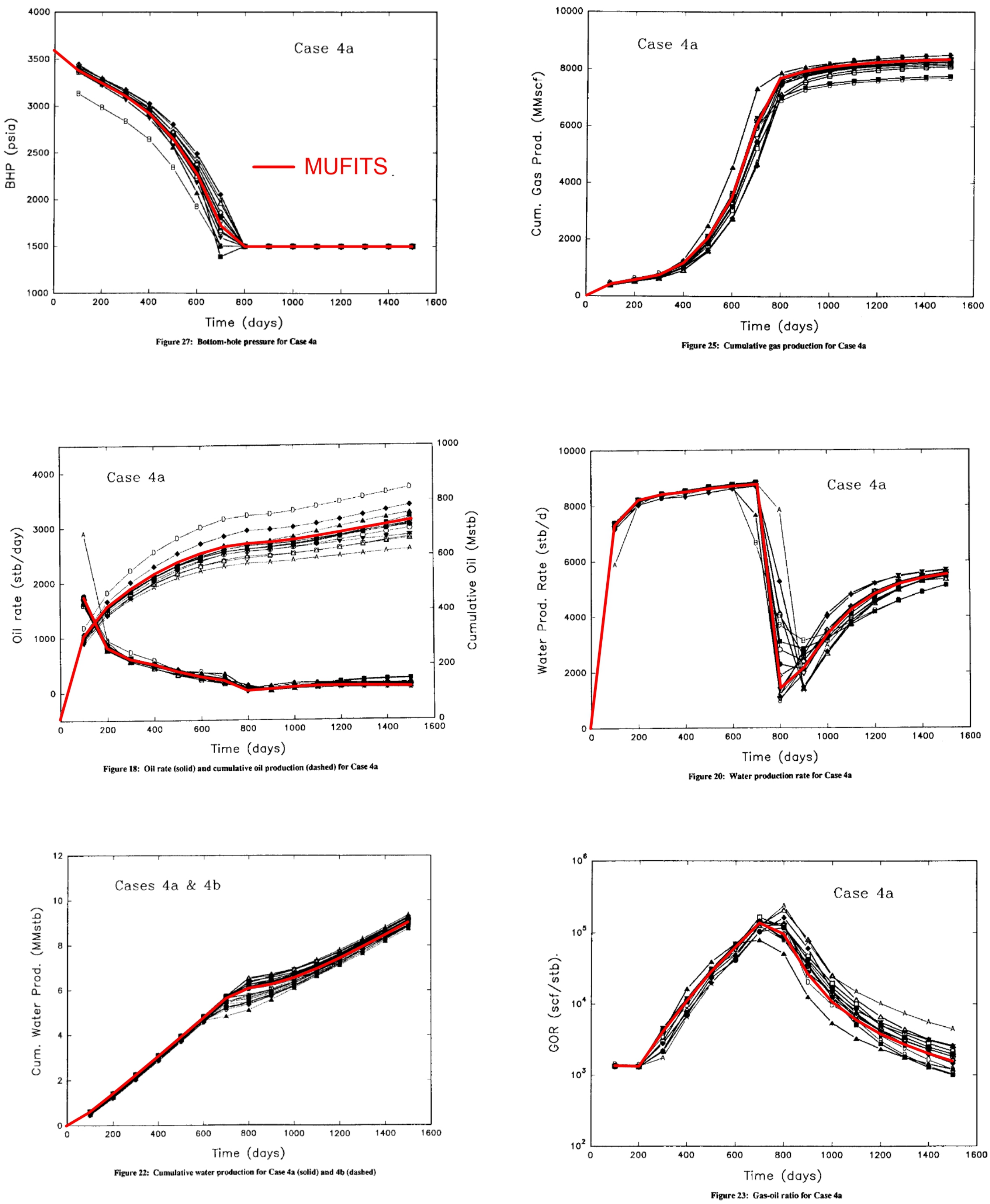

Figure 2.3: Comparison between MUFITS (red curves) and the 7th SPE paper, case 4a (background figures).

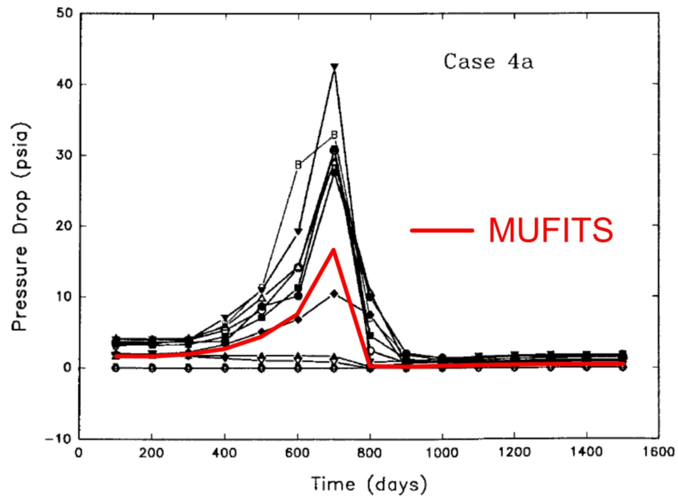

Figure 29: Total pressure drop along wellbore for Case 4a

Figure 2.4: Comparison of pressure drop in the wellbore between MUFITS (red curves) and the 7th SPE paper, case 4a (background figure).

2.4. Case 4b

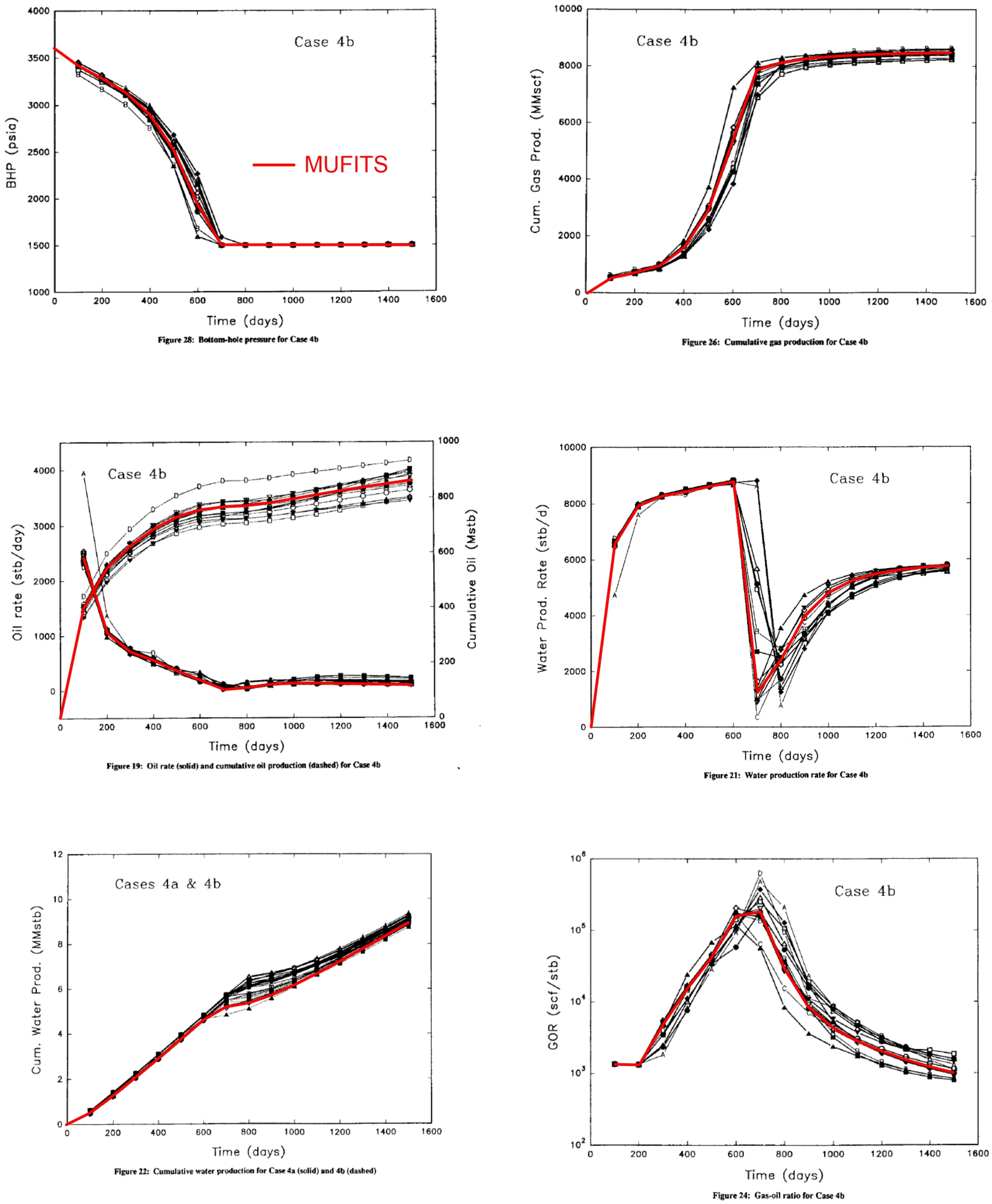

Figure 2.5: Comparison between MUFITS (red curves) and the 7th SPE paper, case 4b (background figures).

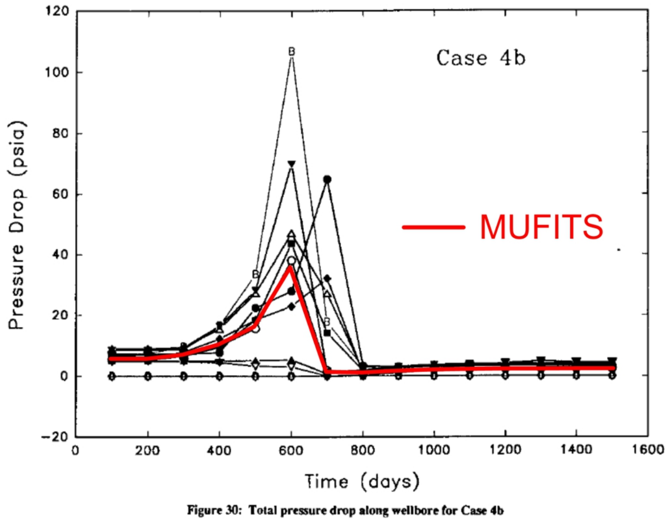

Figure 2.6: Comparison of pressure drop in the wellbore between MUFITS (red curves) and the 7th SPE paper, case 4b (background figure).

References

1. MUFITS reservoir simulator website. http://www.mufits.imec.msu.ru.

2. Afanasyev A. Hydrodynamic modelling of petroleum reservoirs using simulator MUFITS// 2015. Energy Procedia. 76: 427-435. DOI: 10.1016/j.egypro.2015.07.861.

3. Nghiem, L. et al. 1991. Seventh SPE Comparative Solution Project: Modelling of Horizontal Wells in Reservoir Simulation. SPE Symposium on Reservoir Simulation, 17-20 February, Anaheim, California. DOI: 10.2118/21221-MS.