Achieving potential

All your need to maximize your oil & gas production, quick

Case Study
Oil Flowing Material Balance

Mikhail Tuzovskiy, 11.04.2018
mtuzovskiy@pengtools.com
Summary

This Case Study demonstrates the application of the Oil Flowing Material Balance (FMB) engineering technique using the E&P Portal.

The Study is based on the oil well from a field in West Siberia, Russia.

It is shown how to:

- Input the data to the E&P Portal;
- Apply the Oil FMB to estimate the well’s STOIIP and JD;
- Save and export the analysis results.

All the input data is attached to the Case Study for the reference.
Table of Contents

Summary .............................................................................................................................................. 1
Introduction ........................................................................................................................................... 3
Well Data ................................................................................................................................................ 4
Reservoir Data ......................................................................................................................................... 5
Data Input to the E&P Portal ................................................................................................................... 6
  Signing up ........................................................................................................................................... 6
  Adding the “Superior” field .................................................................................................................... 8
  Adding the “B2” reservoir ..................................................................................................................... 9
  Creating the “B2” reservoir PVT model ............................................................................................... 11
  Adding the “B2” reservoir PVT model ............................................................................................... 13
  Adding the well “8” ............................................................................................................................ 15
  Adding the well “8” perforations ........................................................................................................ 17
  Adding the well “8” kh and JD ............................................................................................................. 18
  Upload the well “8” daily production data ............................................................................................ 19
  Adding the well “8” casing design ....................................................................................................... 21
  Adding the well “8” downhole equipment ......................................................................................... 24
  Calculating the well “8” flowing bottomhole pressure ....................................................................... 27
Applying the Oil FMB ............................................................................................................................ 30
  Opening the Oil FMB tool .................................................................................................................. 30
  Matching the well “8” Oil FMB model ............................................................................................... 31
Saving and exporting the analysis results ............................................................................................. 34
  Saving the well “8” Oil FMB model .................................................................................................... 34
  Exporting the well “8” Oil FMB model .............................................................................................. 36
Conclusions .............................................................................................................................................. 38
Introduction

E&P Portal is a service to identify production enhancement opportunities and maximize production and recovery. The average production increase for the last 3 E&P companies applied the E&P Portal was 38%.

Oil FMB is the advanced engineering technique published in 2005 by Louis Mattar and David Anderson. Original paper PDF: Dynamic Material Balance (Oil or Gas-In-Place Without Shut-Ins).

The details on math and physics of the Oil FMB method are published on the wiki page: https://wiki.pengtools.com/index.php?title=Oil_Flowing_Material_Balance

Oil FMB is available at the E&P Portal as one of its engineering workflows. The access to the Oil FMB tool at the E&P Portal is free for the personal use, once sign up at ep.pengtools.com.
Well Data

Well “8” was drilled down to 9240 ft.

Well design: 13 3/8 in conductor down to 101 ft; 9 5/8 in surface casing down to 2699 ft; 7 in production casing down to 9240 ft.

The well “8” was perforated and hydraulically fractured in “B2” reservoir of the “Superior” field on 01.05.2017\(^1\).

The “B2” reservoir was perforated as follows: top MD 8850 ft, bot MD 8897 ft, by “Mega-73 BG” gun with shot density of 6 SPF.

Well completion string is 2 7/8 in down to 8102 ft with the ESP on 7905 ft.

From the log analysis report the well kh is 17.8 md*ft.

The post frac report suggests the well JD is 0.6.

The initial reservoir pressure at the well was measured to be 2689 psia.

The well was put on production with the ESP on 26.06.2017.

The field team routinely gathers the well measures and flow test data (dynamic fluid levels, annular pressures, oil, water, gas flowrates etc.). The ESP intake gauge data is also available through the SCADA system.

The well data is attached as “well 8 daily data.csv”.

\[\text{Figure 1. Well “8” daily data file}\]

\(^1\) Note that the well, reservoir, field names as well as well production data and dates were changed for the purpose of this study
Reservoir Data

The “B2” reservoir data is given below:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STOIIP</strong></td>
<td>128 MMstb</td>
<td></td>
</tr>
<tr>
<td>Conrate water saturation</td>
<td><strong>Sw</strong></td>
<td>35 %</td>
</tr>
<tr>
<td>Rock compressibility</td>
<td><strong>cr</strong></td>
<td>4.36E-6 psia⁻¹</td>
</tr>
<tr>
<td>Initial reservoir pressure</td>
<td><strong>Pi</strong></td>
<td>3262 psia</td>
</tr>
<tr>
<td>Initial reservoir temperature</td>
<td><strong>Ti</strong></td>
<td>212 F</td>
</tr>
<tr>
<td>Oil density</td>
<td></td>
<td>37 API</td>
</tr>
<tr>
<td>Bubble point pressure</td>
<td><strong>Pb</strong></td>
<td>2486 psia</td>
</tr>
<tr>
<td>Solution gas ratio</td>
<td><strong>Rs</strong></td>
<td>1011 scf/bbl</td>
</tr>
<tr>
<td>Gas specific gravity</td>
<td><strong>SGgas</strong></td>
<td>1.2</td>
</tr>
<tr>
<td>Water specific gravity</td>
<td><strong>SGwater</strong></td>
<td>1</td>
</tr>
</tbody>
</table>

*Table 1: “B2” reservoir data.*
Data Input to the E&P Portal

Signing up

First open [ep.pengtools.com](http://ep.pengtools.com) in your browser and signup or login to the E&P Portal.

![E&P Portal landing page](image1.png)

Figure 2. E&P Portal landing page

After signing up /logging in you’ll see the main [E&P Portal](http://ep.pengtools.com) page:

![Main page of the E&P Portal](image2.png)

Figure 3. Main page of the E&P Portal
Check the units in the page footer to be “Field”.

![Figure 4. Field units in the main page footer](image)

Check the current database in the page footer to be “EP Demo”.

![Figure 5. Current database in the main page footer](image)

😊 Now you are ready to start entering the data into the E&P Portal
Adding the “Superior” field

In the left menu open the “Fields” page of the “Subsurface” module:

![Fields page of subsurface module of the E&P Portal](image)

Figure 6. Fields page of subsurface module of the E&P Portal

Click “Create Field”, fill the form as follows and click “Create”:

![Creating the “Superior” field in the E&P Portal](image)

Figure 7. Creating the “Superior” field in the E&P Portal

😊 Now you have successfully added the “Superior” field to the E&P Portal:

![“Superior” field in the E&P Portal](image)

Figure 8. “Superior” field in the E&P Portal
Adding the “B2” reservoir

In the left menu open the “Reservoirs” page of the “Reservoir Management” module:

![Reservoir Management Module](image1)

Figure 9. Reservoirs page of Reservoir Management module of the E&P Portal

Click “Create Reservoir”, fill the form as follows and click “Create”:

![Create Reservoir Form](image2)

Figure 10. Creating the “B2” reservoir in the E&P Portal

😊 Now you have successfully added the “B2” reservoir to the E&P Portal:
Figure 11. “B2” reservoir in the E&P Portal

Note that a number of the reservoir’s parameters are automatically calculated based on the production data loaded to the system.
Creating the “B2” reservoir PVT model

In the top of the page click on the “PVT Tool” page:

![Image of PVT Tool interface]

Figure 12. Opening the PVT Tool in the E&P Portal

Fill the form with the given data as follows and click “Calculate”:

![Image of filled PVT tool form]

The “B2” reservoir PVT model is ready by now. Check the parameters plots on the “Oil”, “Gas” and “Water” tabs. Model results are available in the Output section and the results table on each page.

😊 Click “Save to cloud” to save the model.
The summary of the model parameters is given below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_i$, psia</td>
<td>3262</td>
</tr>
<tr>
<td>$T_i$, F</td>
<td>212</td>
</tr>
<tr>
<td>$S_{G_{oil}}$</td>
<td>0.84 (37 API)</td>
</tr>
<tr>
<td>$S_{G_{gas}}$</td>
<td>1.2</td>
</tr>
<tr>
<td>$S_{G_{water}}$</td>
<td>1</td>
</tr>
<tr>
<td>$R_{sb}$, scf/bbl</td>
<td>1011</td>
</tr>
<tr>
<td>$P_b$, psia</td>
<td>2486</td>
</tr>
<tr>
<td>$B_{o}$, bbl/stb</td>
<td>1.651</td>
</tr>
<tr>
<td>$\mu_{oil}$, cP</td>
<td>0.37</td>
</tr>
<tr>
<td>$C_{oil}$, psia-1</td>
<td>3.66E-6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Z$</td>
<td>0.72</td>
</tr>
<tr>
<td>$B_{g}$, scf/scf</td>
<td>0.004218</td>
</tr>
<tr>
<td>$\mu_{gas}$, cP</td>
<td>0.043</td>
</tr>
<tr>
<td>$C_{gas}$, psia-1</td>
<td>0.00011363713688852</td>
</tr>
<tr>
<td>$B_{w}$, bbl/bbl</td>
<td>1.037</td>
</tr>
<tr>
<td>$C_{w}$, psia-1</td>
<td>3.1981709184194E-6</td>
</tr>
<tr>
<td>$\mu_{water}$, cP</td>
<td>0.29</td>
</tr>
<tr>
<td>Water Density, lbm/ft³</td>
<td>60.180592</td>
</tr>
<tr>
<td>Oil density, lbm/scf</td>
<td>41.7</td>
</tr>
</tbody>
</table>

*Table 2. “B2” reservoir PVT model results*
Adding the “B2” reservoir PVT model

In the top menu open the “PVT” page of the “Reservoir Management” module:

![Reservoirs PVT page of Reservoir Management module of the E&P Portal](image)

Click “Add PVT”, fill the form as follows and click “Create”:

![Creating the PVT model in the E&P Portal](image)

Note that PVT parameters are copied from the PVT model created on the previous step.

Now you have successfully added the “B2” reservoir PVT model to the E&P Portal:
Figure 15. Reservoirs PVT page of Reservoir Management module of the E&P Portal
Adding the well “8”

In the left menu open the “Well” page of the “Subsurface” module:

Figure 16. Well page of Subsurface module of the E&P Portal

Click “Create Well”, fill the form as follows and click “Create”:

Figure 17. Creating the well “8” in the E&P Portal

😊 Now you have successfully added well “8” to the E&P Portal:
Figure 18. Well “8” in the E&P Portal
Adding the well “8” perforations

In the left menu open the “Perforations” page of the “Subsurface” module:

![Perforations page of Subsurface module of the E&P Portal](image)

**Figure 19. Perforations page of Subsurface module of the E&P Portal**

Click “Create Perforation”, fill the form as follows and click “Create”:

![Create Perforation](image)

**Figure 20. Creating the well “8” perforations in the E&P Portal**

😊 Now you have successfully added well “8” perforations to the E&P Portal:

![Well “8” perforations in the E&P Portal](image)

**Figure 21. Well “8” perforations in the E&P Portal**
Adding the well “8” kh and JD

In the left menu open the “kh & JD” page of the “Subsurface” module:

![kh & JD page of Subsurface module of the E&P Portal](image)

Figure 22. kh & JD page of Subsurface module of the E&P Portal

Click “Create Perforation”, fill the form as follows and click “Create”:

![Creating the well “8” kh and JD in the E&P Portal](image)

Figure 23. Creating the well “8” kh and JD in the E&P Portal

😊 Now you have successfully added well “8” kh & JD to the E&P Portal:

![Well “8” kh & JD in the E&P Portal](image)

Figure 24. Well “8” kh & JD in the E&P Portal
Upload the well “8” daily production data

In the left menu open the “Daily Data” page of the “Well Production” module:

![Figure 25. Wells daily data upload page of the E&P Portal](image)

Fill the form as follows and click “Upload”:

![Figure 26. Well “8” daily data upload to the E&P Portal](image)

Wait for the message showing the data upload status:
Now you have successfully uploaded the well “8” daily data to the E&P Portal:

Let’s visually inspect the data uploaded. In the top menu click the “Plot”. Fill the filter as follows and click “Search”:

Figure 28. Well “8” daily data visualization
Adding the well “8” casing design

In the left menu open the “Well Design” page of the “Drilling” module:

![Well Design page of the Drilling module of the E&P Portal](image)

**Figure 29. Well Design page of the Drilling module of the E&P Portal**

Adding the Conductor: Click “Add Equipment”, fill the form as follows and click “Create”:

![Create Well Design Equipment](image)

**Figure 30. Creating Well “8” conductor in the E&P Portal**

Adding the Surface casing: Click “Add Equipment”, fill the form as follows and click “Create”:
Adding the Production casing: Click “Add Equipment”, fill the form as follows and click “Create”:

![Figure 31. Creating Well “8” surface casing in the E&P Portal](image1)

Now you have successfully added well “8” casing design to the E&P Portal:

![Figure 32. Creating Well “8” production casing in the E&P Portal](image2)
Figure 33. Well “8” schematic in the E&P Portal
Adding the well “8” downhole equipment

In the left menu open the “Downhole Equipment” page of the “Downhole Equipment and Artificial Lift” module:

![Figure 34. Well Downhole Equipment page of the Downhole Equipment and Artificial Lift module of the E&P Portal](image)

Click “Create Well Downhole Equipment”, fill the form as follows and click “Create”:

![Figure 35. Creating the well “8” downhole equipment in the E&P Portal](image)

Next click on the “well name” to define the completion string elements:

![Figure 36. Well “8” downhole equipment in the E&P Portal](image)

Click “Add Well Downhole Equipment Element:“
Add the first part of the completion string: Fill the form as follows and click “Create”:

Add the ESP: Fill the form as follows and click “Create”:

Add the last part of the completion string: Fill the form as follows and click “Create”: 
Now you have successfully added well “8” downhole equipment to the E&P Portal:

Figure 40. Adding well “8” tubing bottom in the E&P Portal

Figure 41. Well “8” downhole equipment elements in the E&P Portal

Figure 42. Well “8” downhole equipment in the E&P Portal
Calculating the well “8” flowing bottomhole pressure

In the left menu open the “BHP Calculation” page of the “Calculator” module.

Fill the filter as follows 2 and click “Search”.

![BHP Calculator page in the E&P Portal](image)

**Figure 43. BHP Calculator page in the E&P Portal**

Inspect the BHP calculation results in the results table:

![BHP Calculator results table in the E&P Portal](image)

**Figure 44. BHP Calculator results table in the E&P Portal**

Export the calculated BHP to the daily measures.

In the left menu open the “BHP & Pres - Export to Daily Data” page of the “Calculator” module. Fill the filter as follows and click “Calculate”.

---

2 Then dates filters left empty the calculator processes all the well history
Now you have successfully calculated the well “8” flowing bottomhole pressure in the E&P Portal.

Copyright © Akadem Petroleum Technology Inc. Exploration and Production Portal, 2018
Applying the Oil FMB

Opening the Oil FMB tool

In the left menu open the “Oil FMB” page of the “Engineering Tools” module.

Fill the filter as follows and click “Submit”.

![Image of Oil FMB tool]

Figure 48. Oil Flowing Material Balance in the E&P Portal

Inspect the Oil FMB Results. Note that STOIIP and JD correspond to the input data.

Also note that oil FMB model (red and gray curves) doesn’t match the well’s data points.

This means that well “8” is draining only a part of the reservoir “B2” reserves and the post frac report JD of 0.6 is over estimated.

![Image of Well “8” Oil FMB]

Figure 49. Well “8” Oil FMB in the E&P Portal

😊 Now well “8” oil FMB model is ready to be matched with the well data to find the actual well’s STOIIP and JD.
Matching the well “8” Oil FMB model  
To increase details  
First STOIIP should be reduced. Drag and drop the red line end point to the 10M.

**Figure 50. Well “8” Oil FMB changing the STOIIP to 10M**

Inspect the Oil FMB plot with STOIIP = 10M bbl:

**Figure 51. Well “8” Oil FMB STOIIP = 10M**

At this step change the “Data Usage” to 100% in the model inputs to increase the details of the plot:
Figure 52. Changing the Data Usage of the Oil FMB plot in the E&P Portal

Inspect the Oil FMB plot with STOIIP = 10M bbl and increased data usage:

Figure 53. Well “8” Oil FMB STOIIP = 10M and data usage = 100%

STOIIP should be reduced further. Drag and drop the red line end point to the 3M.

Figure 54. Well “8” Oil FMB STOIIP = 3M

STOIIP should be reduced further. Drag and drop the red line end point to the 2M.

Figure 55. Well “8” Oil FMB STOIIP = 2M

Next JD should be reduced. Drag and drop the gray line end point to match the gray points:
Inspect how the current Oil FMB model matches the well data:

Figure 56. Well “8” Oil FMB changing the JD to 0.5

Now well “8” oil FMB model is matched and the results are:
- **STOIIP** = 2 mln bbl
- **JD** = 0.5

Figure 57. Well “8” Oil FMB matched model
Saving and exporting the analysis results
Saving the well “8” Oil FMB model

Click “Save Model:

![Figure 58. Saving the well “8” Oil FMB matched model](image)

The dialog confirms that the model was saved:

![Figure 59. Saving Oil FMB model dialog](image)

😊 Now well “8” oil FMB model is saved to the E&P Portal database.
Figure 60. Saved well “8” Oil FMB model in the table
Exporting the well “8” Oil FMB model

Check the “Show Table” select box in the model inputs and click “Submit”.

Figure 61. Selecting the Oil FMB table for output

Scroll below the main Plot to see the calculation results table:

Figure 62. Oil FMB results table in the E&P Portal

Click to the export button on the top right corner of the table and select the output format you want the data in:
Figure 63. Exporting the Oil FMB results table from the E&P Portal

Open the downloaded file “epDataExport.xlsx”:

Figure 64. Exporting the Oil FMB results in Excel spreadsheet
Conclusions

This Case Study demonstrated application of the Oil Flowing Material Balance to estimate well “8” STOIIP and JD using the E&P Portal.

A step by step guide was presented to assist users along the way of using the E&P Portal and Oil FMB tool.

The following steps were covered:

- Input the data to the E&P Portal;
- Apply the Oil FMB to estimate the well’s STOIIP and JD;
- Save and export the analysis results.

As usual, data preparation and upload step took the most time an effort, while the analysis part once data is processed was relatively easy and quick.

Imagine the power of the E&P Portal then data continually flows to the system for the hundreds and thousands of wells and ready for the analysis like the Oil FMB and others in the live mode!

With the help of the E&P Portal you can quickly analyze the big number of wells saving the engineering time while increasing the well’s and field’s production and company’s revenues.