Dynamic Modeling of Gas-Lift

Bin Hu, OLGA Product Champion
SPT Group, A Schlumberger Company
Back to the API gas-lift workshop after 10 years!

Characterising Gas-lift Instabilities with OLGA2000

ASME/API/ISO Fall 2003 Gas-Lift Workshop
21-22 October 2003, Kuala Lumpur

Abstracts, Presentations and Papers
Copies of abstracts, presentations, and papers will be placed in this section as they become available.

Legend
Blue = Accepted
Green = Final
Grey = Pending

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Contact Address
EnCyclops
Zack Ibrahim
Gas-Lift Optimization Process

Gas-Lift Automation
1. Poon-eve
Wadee Bulter
David Sweneman
Automating Flow Control on Gas-Lift Wells
Abstract
Presentation

2. Shell Global Solutions
Nqmi Mabadi Noor
Gas Coning Control and Gas-Lift Stabilization in Shell Gabon
Abstract
Presentation
Contents

• What is dynamic simulation and why it is important for wells

• Key components of the dynamic modeling of gas-lift

• Three recent application examples
  – Unloading (wellbore cleanup)
  – Gas robbing in dual completion
  – Water-cut limits
Applications are booming!

OLGA-for-Wells papers - yearly statistics (1990~)

Integrated Wellbore/Reservoir Model Predicts Flow Transients in Liquid-Loaded Gas Wells

An integrated wellbore/reservoir model was used to investigate liquid loading in a gas well. The model produces from a storage reservoir, and it experiences water coming from an aquifer. The integrated model showed how the water that is caused by the gas flow into the gas well, and the experience water coming from an aquifer. The model was used to investigate liquid loading in the wells to increase. Depending on reservoir conditions, the well may enter into a state of unsteady production, thereby the gas flow into the gas well, the pressure can be controlled between the production rate and the liquid holdup in the wells to increase.
Why is the transient well flow simulation getting important?
Key components of the dynamic modeling of gas-lift

- Transient multiphase flow modeling in both tubing and annulus
- Thermal interactions between fluid flow in annulus and tubing
- Downstream and upstream boundary conditions
- Realistic initial condition
- Phase behavior and PVT
- Characteristics of chokes and GLVs
OLGA now has the VPC capability.

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21 March 2011

Report on Verification of VPCTM code for SPT Group

SPT Group contacted Decker Technology, Inc for the purpose of verifying the VPCTM correlations in the OLGA™ software. This was accomplished during the period of March 15-17 at the offices of SPT Group in Kjeller, Norway.

The VPCTM correlations and a sample database had been sent previously. Upon arrival, the code had been converted to C++. The purpose of the trip was to verify that the flow rate calculations from the converted code matched that of the VPCTM software.

In summary, the VPCTM correlations were verified in the OLGA™ code. SPT Group can now advertise the use of VPCTM correlations.

SPT Group is not a member of the VPCTM and does not have licenses for the database. It was made very clear to principals of the SPT Group that the database could not be used by SPT Group for consulting purposes. SPT Group agreed and assured Decker Technology, Inc that they would not use the database and would not re-distribute the database to clients without first verifying that the clients had license to the database.

With regard to support of the VPCTM correlations for clients that do have access to the VPCTM database, SPT Group can use the database.

With regard to use of the VPCTM database for the purpose of training, SPT Group does not have access to the database. The contracts signed by VPCTM members and Decker Technology, Inc do not specifically allow the use of the database for training purposes. Only VPCTM members or clients with licenses are allowed to use the database.

SPT Group requested that Decker Technology, Inc discuss the issue of the use of the VPCTM database for the purpose of training. This subject will be brought up at the next VPCTM Annual Meeting.

Regards,
Ken Decker
VPCTM Administrator
Now it takes only 10 seconds to set up a GLV in the OLGA model.

The dropdown list of the valves in the database.
Real application example 1

Unloading

- Simulate unloading using gas lift and for an oil well
- Well completed with 9.3 ppg brine
- 2 inch choke with a maximum CV of 86
- Start with 24/64” and bean up with 4/64” every two hours until 64/64”
- Well will flow to LP separator at 60 psig
- CHP of 600 psig
- Predict clean-up time and efficiency
Wellbore cleanup (unloading) assisted by gas-lift – three phase holdup profiles from the simulation
Dynamic simulation shows gas lift multi-pointing
Conclusion of the unloading simulation

• The planned operation can clean out the completion fluid
  – Despite of multipointing during operation
  – The GLV selection and spacing are both however recommended to be reviewed with realistic CHP

• Flow instability during the unloading can happen with the current design
Real application example 2
Gas robbing in dual completion

Normal Operation

Robbing

Detrimental to Production
Accurate prediction important
Transient Phenomenon
Investigation of Gas-lift Robbing

- Can the robbing phenomenon be simulated?
- If yes, what is the operating envelope prone to robbing?
- What will be the optimum gas-lift injection rate to operate under these circumstances?
- What will be the effect of dummying off (closing the GLVs and orifice) the robber string?
Robbing happens when lift gas rate is reduced to 0.5 Mmscfd.
Variation of total oil production with gas-injection rate

Graph showing the variation of total oil production (STB/d) with total lift-gas injection rate (MMscfd). The graph includes two curves:
- **Oil Rate**
- **Split Factor**

Key points:
- Optimum oil rate around 106 STB/d.
- The split factor peaks at a certain injection rate, indicating an optimum point for oil production.

The graph helps in understanding the trade-off between gas injection rate and oil production efficiency.
Effect of Dummying off the Short String

- 2% less oil
- 58% less gas
Conclusions on gas robbing simulation

- Dynamic modeling is used to model and predict gas-lift robbing in a dual string oil well
- Short string nearly robs all the gas at gas injection rate of 0.5 MMscfd
- Optimum lift-gas injection rate should be close to 1 MMscfd and results in more than 100 STB/d gain as against an injection rate of 0.5 MMscfd.
- Dummying off the short string slightly reduces the oil production but the gas lift rate is significantly reduced as summarized below

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Total production [Stb/d]</th>
<th>Optimum gas injection rate [MMscfd]</th>
</tr>
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<tbody>
<tr>
<td>Both strings gas-lifted</td>
<td>1045</td>
<td>1</td>
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<tr>
<td>Short string dummied</td>
<td>1023</td>
<td>0.42</td>
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</table>
Water-cut Limit - Scenario

- Offshore well with...
  - Increasing water-cut
  - Above bubble point
  - Limited start-up gas lift supply
  - Tubing diameter 5 ½ X 4 ½ inch, liner diameter 7 inch
  - TD at 9000 ft MD 8800 ft TVD
  - Limited PVT data

- What is the maximum water-cut at which the well can...?
  - Flow naturally?
  - Restart naturally?
  - Restart with gas lift?
  - How much lift gas is required?
  - What is the time required to resume production?
  - Can restart be achieved by reducing separator pressure temporarily?
Water-cut Limit – Wellbore configuration

Tubing start depth: 114.361 m
Tubing total measured depth: 2703.58 m

<table>
<thead>
<tr>
<th>Section length [m]</th>
<th>Tubular component name</th>
<th>Inner diameter [in]</th>
<th>Outer diameter [in]</th>
<th>Density [kg/m³]</th>
<th>Heat capacity [J/kg·°C]</th>
<th>Conductivity [W/m·°C]</th>
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<tr>
<td>2016.68</td>
<td>BEAR 5 1/2&quot; KOHP2...</td>
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<td>7840</td>
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<table>
<thead>
<tr>
<th>Type</th>
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<th>Top MD [m]</th>
<th>Bottom MD [m]</th>
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<tr>
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<td>10 3/4&quot; L/N80 60.7 lbs/ft</td>
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<td>452.933</td>
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<tr>
<th>Length [m]</th>
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<td>Valve</td>
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Water-cut Limit– Definitions
Water-cut Limit – Key conclusions

<table>
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<tr>
<th>Wellhead [ barg ]</th>
<th>Natural flow Watercut limit [ % ]</th>
<th>Natural Restart Watercut limit [ % ]</th>
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<tbody>
<tr>
<td>30</td>
<td>85</td>
<td>75</td>
</tr>
<tr>
<td>40</td>
<td>70</td>
<td>55</td>
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<tr>
<td>50</td>
<td>55</td>
<td>45</td>
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</table>
Water-cut Limit – Key conclusions

GA-P2 Restart gas lift wc=70%, Pwh=40barg

- Accumulated volume [Mscf]
- Gas lift flowrate [Mscf/d]
- Time [Minutes]

Nitrogen lift gas consumption
Lift time
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