Horizontal Well Artificial Lift Projects (TUHWALP)

TUHWALP Overview

Cem Sarica
Outline

- Mission
- Significance
- Challenges
- Interest
- Research & Development Plan
- Scope
- Schedule
- Budget
Mission

Work with the Petroleum Industry to

- Advance knowledge and effectiveness of people who design and operate horizontal oil and gas production wells

- Develop recommended practices for artificial lift of horizontal wells that
  - Optimize recovery of oil, natural gas, and associated liquids from horizontal wells
  - Improve the selection, deployment, operation, monitoring, control, and maintenance of artificial lift equipment
  - Improve design and operability
Significance

- Significant Natural Gas and Oil Potential from Shale
Significance …
Significance...

Number of Marcellus Shale Wells Drilled in Pennsylvania by Calendar Year

Number of Producing Barnett Shale Wells Over Time as of January 1, 2008
All Counties/Fields in the Fort Worth Basin

TUHWALP – McDougall School of Petroleum Engineering
February 21, 2012
Challenges

- Much of the water used to fracture the wells must be recovered to reduce back-pressure and clear the flow paths for gas and oil production.
- Most artificial lift systems are designed to work in the vertical sections of wells.
- Methods must be developed to help sweep and lift fluids from the deviated and/or horizontal portions of the wellbores.
- Most “horizontal” wells are not actually horizontal.
Challenges ...
Challenges …
Challenges …
Challenges …

- Often the “horizontal” portions of the wells have up and down undulations
  - Water can accumulate in the low spots and then be produced to the “vertical” part of the well in slugs.
  - This can make artificial lift challenging, especially when pumping systems are used.
- Reasonable methods exist to determine the “critical” gas flow velocity needed to lift liquid out of vertical gas wells.
- There is a need for improved understanding and models to determine the “critical” gas flow velocity in horizontal wells.
Interest

- An early survey of interest through a questionnaire developed and circulated amongst a group of interested companies with the leadership of ALDRC

- Following potential project subjects listed as ranked (on average) by the respondents
Interest …

a) Select optimum method(s) of artificial lift for horizontal wells
b) Understand flow regimes and critical rates in horizontal wells
c) Recommend optimum horizontal well geometry and wellbore trajectory
d) Recommend placement of end-of-tubing, location for artificial lift (pump, gas lift), and casing size
e) Summarize industry learning’s and literature information
f) Recommend when to start artificial lift operations in horizontal wells
g) Develop training materials and courses for Engineers and Operators associated with horizontal wells
Consortium R&D Plan

Four main projects lines

- Investigation of Multiphase Flow Behavior in Horizontal Gas Wells
- Investigation of Artificial Lift Techniques in Horizontal Gas Wells
- Development of Guidelines and Recommended Practices for Horizontal Gas Wells
- Investigation of Multiphase Flow Behavior in Horizontal Oil Wells
Scope – Project-1

Investigation of Multiphase Flow Behavior in Horizontal Gas Wells

Drivers

- Horizontal Wells are Undulated
- No Loading Criteria is Established for Horizontal Wells
- Understanding the flow behavior is a pre-requisite for any design and artificial lift consideration
Objectives

- Investigation of the multiphase flow characteristics for horizontal gas wells experimentally/theoretically and how they are affected by well geometry or trajectory.
- Development of mechanistic liquid loading criteria for horizontal gas wells.
- Based on the developed criteria, development of a predictive software tool for liquid loading.
Plan – Project-1

- Experimental Study
  - Operating conditions of horizontal wells will experimentally be simulated using a 2 in. ID facility
  - Facility will include
    - Two undulations (one undulation consists of one downward and one upward inclined pipe with a dip)
    - Gas and liquid feeds along the test section to mimic the horizontal well fractures
    - Toe-up and toe-down configurations
    - Proper instrumentation
Plan – Project-1 …

- Experimental Study …
  - Testing program
    - Various gas and liquid flow rate combinations typical of horizontal well production to investigate the liquid loading/unloading
    - Toe-up, toe-down and flat configuration will be studied
    - Detailed test matrix will be developed later based on the final configuration of the test section
  - Testing is expected to produce an experimental map of liquid loading
Plan – Project-1 ...

- **Modeling**
  - A mechanistic model (physics based) to predict the liquid loading will be developed
  - Experimental results will be utilized in model development
  - Software to predict loading region based on the modeling
Scope – Project-2

Investigation of Artificial Techniques in Horizontal Gas Wells

- Drivers
  - Classical artificial lift methods include velocity strings, surfactant utilization to promote foaming (soap sticks or liquid soap injection), beam pumping, plunger lift, and gas lift
  - Several methods have been tried in horizontal wells based on trial and error
  - Performance and applicability of each artificial lift technique will be strongly influenced by the multiphase flow behavior and distribution of the fluids in the horizontal well
Scope – Project-2 ...

Objectives

- Acquire field data and summarize field practices
- Experimentally and theoretically investigate the performance of various unloading techniques
- Develop performance evaluation tools based on flow dynamics and well construction profile
- Generate an unloading method selection criteria road map based on field data, and experimental and theoretical results
Plan – Project-2

- Experimental Study
  - Operating conditions of horizontal wells will experimentally be simulated using a large scale experimental facility
  - Facility will be designed and constructed with the following features
    - Two undulations
    - Large pipe diameter between 4 in. or 6 in.
    - Gas and liquid feeds along the test section to mimic the horizontal well fractures
    - Toe-up and toe-down configurations
    - Ability to incorporate and test various artificial lift methods
Plan – Project-2 …

- Experimental Study …
  - Testing Program
    - Expected to produce efficacy of various artificial lift methods
    - Performed for various gas and liquid flow rate combinations that are typical of the liquid loading
    - Detailed test matrix will be developed later based on
      - Final configuration of the test section
      - Artificial lift methods to be investigated
Plan – Project-2 …

- Modeling
  - A mechanistic model (physics based) to predict the efficacy of various artificial lift methods
  - Experimental results will be utilized in model development
Scope – Project-3

Development of Guidelines and Recommended Practices for Unloading Horizontal Gas Wells

Drivers

- Currently, the guidelines and recommended practices developed for vertical and deviated wells are used for horizontal wells
- Basic guidelines and recommended practices for the unloading of horizontal gas wells are needed
- No concerted effort to develop the basic guidelines and recommended practices.
Objectives

- Develop guidelines and recommended practices for the selection of the proper artificial lift techniques
Plan – Project-3

- Gather data on field practices in horizontal well unloading
- Develop a database on the performance of various field artificial lift practices
- Test the performance of various practices with the model simulations
- Develop the guidelines and the recommended practices based on the above items
Investigation of Multiphase Flow Behavior in Horizontal Oil Wells

Drivers

- There are no tools to predict the behavior of oil dominated multiphase flow in undulating horizontal wells
- Understanding of the flow behavior is key in the design and operation of artificial lift systems
Scope – Project-4 ...

- Objectives
  - Study multiphase flow characteristics for horizontal oil wells experimentally/theoretically
  - Investigate how the well geometry or trajectory affects the flow
Plan – Project-4

Experimental Study

- Operating conditions of horizontal wells will experimentally be simulated using the 2 in. facility after the completion of gas-dominated flows.
- Testing will be performed for various gas and liquid flow rate combinations that are typical of horizontal oil well production.
- Testing is expected to reveal flow behavior that will help decide optimum production of the horizontal well.
Plan – Project-4 …

★ Modeling

- A mechanistic model (physics based) to predict the flow behavior
- Experimental results will be utilized in model development
Project Deliverables

- Project-1
  - Understanding of the liquid loading for horizontal wells
  - A new liquid loading criteria
  - Experimental data
  - Efficiency of self-unloading
  - Guidance to determine optimum horizontal well geometry from unloading perspective
Project Deliverables ...

- **Project-2**
  - Unloading performance of various artificial lift methods and their comparative analysis
    - Tubing insert
    - Gas-lift
    - Surfactants
    - Pumping systems
    - Impact of slugging
  - Experimental data
  - Analysis of setting location of artificial lift equipment
Project Deliverables ...

- **Project-3**
  - Database consisting of both field and experimental data
  - Analysis of the data
  - Guidelines and recommended practices based on field and experimental data
Project Deliverables ...

- Project-4
  - Understanding of the oil dominant flow behavior of horizontal wells
  - Experimental data
  - Model describing the flow behavior
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## Budget

- **Yearly budget is set at $1,000,000**
- **Initial yearly membership fee is set to be $50,000 based on an expectation of having 20 member companies**

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<tr>
<th>Expense Item</th>
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<th>Year Two</th>
<th>Year Three</th>
<th>Year Four</th>
<th>Total</th>
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<td>Salaries and Wages</td>
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<td>Other Direct Cost (Equipment, Supplies, etc.)</td>
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Current Membership Status

- One Signed Member
- Seven More in Process
- Expect to Reach 20 Members within a Year