Management Issues

“Value from Advanced Wells” JIP

April 2015

Project Directors: David Davies & Khafiz Muradov

Team Members: Misfer Almarri, Akindolu Dada, Morteza Haghghat, Eltazy Khalid, Reza Malakooti, Ehsan Nikjoo and Bona Prakasa
VAWE Contract terms 2014 - 2016

- Sponsors requested continuation of IWFsT type research work for a further 3 years
- JIP name changed to “Value from Advanced Wells”
- JIP price:
  - £ 40,000/yr. for 3 years for all sponsors plus
  - New joiners purchase previous deliverables (£ 25,000)
- Other contract conditions unchanged
JIP Management and Reporting:

1. **JIP Steering Committee Meetings**
   - Twice per year (normally April & October)
   - Hard copy of slides provided at the meeting
   - DVD sent ~1 month after the meeting following approval of “Management Issues” *(once signed contract arrives at HWU)*

2. **Sponsor Steered Projects**
   - Sponsor steered projects of great value to the JIP
     - *Highly valued by project staff and PhD students*
   - Only results shared with JIP, not sponsor IP (e.g. reservoir model)
   - Larger projects to be proposed by JIP member for approval
   - Visits to sponsors welcomed, charged at “out-of-pocket cost”

3. **Reporting**
   - JIP Meetings review status at 6 monthly intervals
   - SPE Papers
   - Software {Open Source - Microsoft Office if possible plus MATLAB}
   - Scientific publications
Publications 2014

**Conference papers:**

1. **SPE 167818** “Optimal Well Work-over Scheduling: Application of Intelligent Well Control Optimisation Technology to Conventional Wells” Intelligent Energy April 2014, Utrecht Highlighted in JPT May 2014

2. “Reservoir Uncertainty-tolerant, Proactive Control of Intelligent Wells” ECMOR XIV (14th European Conference on the Mathematics of Oil Recovery), September 2014.


5. **IPTC 17977** “Performance of Autonomous Inflow Control Completion in Heavy Oil Reservoirs” IPTC Dec 2014, Kuala Lumpur. REVIVAL

Publications 2014

Presentations:

4. “Combined surface and subsurface control adds value during production of wells subject to gas coning”, SPE Integrated Intelligent Completions Workshop, Rio de Janeiro, September, 2014

Journal Publications:

2. “Proactive Optimization of Intelligent Well Production Using Stochastic Gradient-Based Algorithms” submitted to SPE Reservoir Evaluation & Engineering J. (under review)
Publications 2015

**Conference Presentations**

1. “Maximising the Accuracy of Flow Rate and Reservoir Description of an Intelligent Well’s Multiple Producing Zones through Real-Time, Well-Test Design”, *Devex*, May 2015, Aberdeen

**Conference papers:**


**Journal Publications:**

1. “Reservoir Uncertainty-tolerant, Proactive Control of Intelligent Wells” ECMOR XIV Computational Geoscience Special Issue, *accepted subject to revision*.

2. “A Stochastic Approach for evaluating where On/Off Zonal Production Control is efficient”, *Journal of Petroleum Science and Engineering (JPSE)*, *accepted subject to revision*. 
**VAWE 2014 - 2016 Project Ranking and Status Summary**

April 2015

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<tr>
<th>#</th>
<th>“Value Added by Advanced Wells” (2014-2016) JIP Project Ranking</th>
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| 4 | IWFsT field design workflow | ● Explore completion types and production/reservoir configurations  
   ● (full) field dynamic reservoir modelling of multiple ICV/ICD/AICD/AICV advanced well completions | Design and modelling guidelines | Bona, Eltazy, Morteza | M/H |
| 5 | Advanced injector design | ● Can (A)ICD improve injection performance when fractures are a problem?  
   ● Which (A)ICD and AFI design is the best?  
   ● Acid stimulation in (A)ICD/V completion | Modelling, design guidelines, case studies | Bona, Misfer | H |
| 6 | Identify reservoir types suitable for optimal well/field control types | ● Extend IWFsT v value & application envelope to provide specific completion designs  
   ● Do they apply to brown fields?  
   ● Are lower cost I-well solutions suitable? | Review & workflow for well completion selection | Eltazy, Morteza | M+ |
| 7 | I-Single and I-Multilaterals | Explore how different well trajectories affect the optimal design of an I-completion | See projects 2, 4 & 6, lower sponsor interest | M |
| **Theme 3** | | **Reservoir and Production Monitoring** | | |
| 8 | DTS and/or multiple sensors for In-well MPFM | Develop an integrated in-well Multi-Phase Flow Monitoring for all well types based on Distributed Temperature Sensing with one or more individual Pressure or Temperature gauges or any combinations. | Algorithms, case studies and Guidelines | Khafiz, Reza | H |
| 9 | Pressure & Temperature Transient Analysis | Extend available fundamental solutions for temperature analysis as a complement to Project 8 together with available Pressure Transient Analysis solutions. | Solutions, Case Studies and Algorithms | Akindolu, Khafiz, Ehsan | H |
| 10 | Acoustic Sensing | Distributed Acoustic Sensing as aid to DTS to quantify flow in advanced wells | See MANTICORE project, lower sponsor interest | M/L |
| 11 | Sponsor Suggestions | | | |
| a | Inflow/outflow Management | | | TBC |
| b | N4 well monitoring study | Advanced wells 2.0: ICV/ICD/AICD/AICV design, ICV trim, control & monitoring | Temperature Monitoring Case Study | Started Khafiz | TBC, TBC, N, W, |
| c | W Field full field model | More case studies for light oil/gas situations | (A)FCD Full Field Modelling | Stage 1 completed Bona, Eltazy | W |
| d | Case studies on heavy oil development | S-2 and other case studies of heavy oil/water development with AFCD completion modelling and design | (A)ICD Modelling Guidelines & analysis | Completed Eltazy | S |

**TBC**: To Be Confirmed
Objective: Reducing uncertainty by:

Robust Control: Multiple realisations of the reservoir model

Real-time well information

Achievements:

Framework developed and applied to N Field:

1. **Reactive control strategy** employing critical water-cut (applied to I-wells in N-field) and oil/water production potential

2. **Robust Proactive Optimisation** capturing reservoir uncertainty with a limited number of realisations applied to test case and full-field (N-Field)

Plan:

- Combined strategy tested and applied to a full-field model
  - ✔ Project completed
Objective:
(1) Identify the application area of Proactive and Reactive optimisation
(2) Developing fast and Robust Proactive optimisation algorithm
(3) Developing effective Reactive control strategy

Achievements:
(1) **Stable Reactive Control Strategy** developed
   Compared with commercial alternatives (SPE 154472)
(2) **Guideline:** Proactive → during the plateau period
    Reactive → after the plateau (Applied to N-field)
(3) **Algorithm:** Proactive optimisation algorithm based on stochastic estimation of gradient → Fast, robust, independent of choice of the simulator (ECMOR XIV)
   Compared with commercial alternatives (SPE 167453)

Plan:
- Combined strategy tested and applied to a full-field model
  - ✔️ Project completed
Theme 2 - Advanced Well Design
Project 4 - IWFsT field design workflow

Objective:

(1) Explore completion types and production/reservoir configurations.
(2) AWC Improved modelling accuracy.
(3) (Full) field dynamic reservoir modelling of ICV/ICD/AICD/AICV completions

Achievements:

✓ Analytical model relating productivity ratio to ICD strength required for specified level of inflow imbalance developed (SPE-1775448)
✓ Autonomous inflow control modelling and added value (SPE170780)
✓ Packer placement in ICD wells (SPE17716)
✓ Developed new annular stratified flow model of autonomous inflow device performance.

Plan:

1) Type curve for ICD’s inflow equalisation vs. reservoir heterogeneity index developed.
2) Evaluate the accuracy of the current AICD(V) modelling techniques at the appropriate level of detail and develop new modelling solutions.
3) Extend current packer placement design methodology
Objective:

1) Evaluate the conditions leading to Thermally Induced Fractures
2) Identify the strengths and weaknesses of ICD vs. ICV for controlling thermal fractures
3) Can known techniques for managing Uncertainty be applied to the evaluation of thermally induced fractures?

Achievements:

✓ Study of the impact of Thermal Fractures growth in horizontal wells being studied conditions

Plan:

1) Develop a workflow for ICD completion design optimisation in environments with thermal induced fractures
2) Evaluate the accuracy of current Thermal Fracturing models and develop new modelling solutions where required.
Theme 2 - Advanced Well Design
Project 6 - Identify reservoir types suitable for optimal well/field control

Objective:
(1) Extend the application envelope to provide specific completion design
(2) Improve guidelines for selection between passive and various active AWCs.
(3) When are lower cost I-well solutions suitable?

Achievements: Guidelines
✓ Autonomous (AICD/V) vs fixed (ICD) control devices: Greater added-value of autonomous control in high heterogeneity, compartmentalised reservoirs and uncertain operational/reservoir conditions (SPE170780-MS - IPTC 17977-MS)
✓ Variable (ICV) vs fixed (ICD) control devices: Greater added-value of ICV in uncertain operational/reservoir conditions resulting non-optimum well location.
✓ I-well vs conventional well: Greater added-value of I-well with increasing uncertainty (SPEREJ)

Published Modelling Techniques:
1. Light oil – Gas shut off
2. Heavy oil – water & gas shut-off
3. SAGD Steam breakthrough control (in progress).
   ➢ Only single phase flow data & performance curves used

Plan:
1. Evaluate Autonomous (AICD/V) vs. variable (ICV) control devices
2. Is combined well placement & completion/control optimisation essential for maximum Added Value?
Theme 3: Reservoir & Production Monitoring
Project 8 DTS and/or multiple sensors for In-well MPFM

Objective:
Develop monitoring methodologies to allocate multi-phase flow rates in multi-zone IWs using integrated measurements

Achievements
1. Develop the semi steady state wellbore and near-wellbore P&T model for AWC. Apply this simulator for soft, MPFM in I-wells
2. Develop a range of DTS and DTS+P gauge methods for AWC flow rate, Pr, and PI profiling.
3. Investigate the potential of acoustic data in phase changes and location of inflow points along the wellbore.
4. Develop active, soft MPFM. Use transient P and steady-state P&T. Apply the algorithm to synthetic & real cases.
5. Integrated monitoring & control in multi-zone IWs.
6. Test the algorithm for optimisation of different objective functions.

Future Plan (2014-2016):
- Apply the developed workflows to further sponsor cases
- Develop modified T and P interpretation methods where necessary

Required Data set:
- Annular/tubing P/T & well rate measurements from the history of flow tests in a multi-zone IW
- Well schematic, ICVs specifications, reservoir rock & fluid properties increases the study’s value
- DTS data

Preliminary analysis of initial data set reported
Problem Statement / Objectives

- Monitoring and control of i-wells depends on a robust and accurate analysis of the acquired data.
- Develop of a robust, field deployable (i.e. portable, fast, accurate, user friendly, etc.) PTTA system that integrates with existing soft MPFM workflows for the analysis of single and multi-phase flow.

Builds on

- Temperature transient analysis for liquid producing wells; and steady state zonal rate allocation using pressure and temperature data (2007-2013)

Achieved (April 2015)

- Develop and validate numerical model for transient P&T calculation in gas wells
- Numerical and analytical pressure and rate multi-phase transient analysis in advanced wells

Plan 2014 - 2016

- Developing TTA solutions for gas and gas-liquid producing wells provide the basis for zonal P & Q TA
- Integrate the P & QTA and TTA for 3-phase flow analysis and any-geometry wells
- Validate and develop a usable, universal PTTA workflow; possible integrated with soft MPFM

Data sets required from sponsors

- Reservoir models with corresponding well pressure, temperature and production data, to be used in model verification.
Modern, Applied INerpretation of In-well Temperature with Input from ACOustic Sensing Results (MANTICORE)

Dr. Khafiz Muradov & Prof. David Davies

- **General summary**
  - Develop a user-friendly software based on classical and modern methods to interpret real-time, in-well DTS data.
  - Optional input from DAS will be possible to improve the interpretation quality.

- **Funding Requested** (£287k)

- **Total Project Cost** (£287k)

- **Duration**: 24 months

- **Key impact includes**:
  - Added value from modern in-well sensors (includes DTS, DTS/DAS or similar)
  - Detailed well and reservoir monitoring
  - Reduced number of well interventions

Modern in-well sensors offer a range of measurements:

User-friendly, modern, integrated DTS + DAS interpretation tool to unlock the sensor’s full potential of efficient well performance monitoring:

- **Example DTS signal**
- **Example DAS signal**

(from Glasbergen et al., 2009)  
(from Molenaar et al., 2011)
Average well costs, particularly for marginal and/or unconventional fields, have rapidly increased over the preceding decade. High cost, extensive reservoir contact wells that develop low quality, possibly multi-layer, reservoirs has encouraged the development of real time, in-well, monitoring technologies that diagnose and monitor well/reservoir performance. Well intervention numbers are reduced by targeted interventions that extend the well’s lifetime and maximise the investment return.

Modern, in-well sensors often produce large quantities of raw measurements which are meaningless unless trained staff with appropriate interpretation tools and available to understand the signal and derive parameters such as flow rate, phase cut profile, sand and/or water production interval identification, liquid loading, artificial lift behaviour, etc.

The recent introduction of in-well DTS/DAS sensors offers unique insights into well/reservoir performance. However, the suitable methods to quickly process and interpret the acoustic data are lacking, while cumbersome and/or obsolete of temperature interpretation methods have not yet allowed fully unlocking the full potential contained in DTS/DAS data.

This project aims to integrate the classical with the recently published DTS/DAS interpretation methods in a user-friendly software to help engineers understand, evaluate and interpret DTS (with or without DAS) measurements.

The project will interest reservoir engineers, well completion, production and monitoring engineers and sensor manufacturers.

1. Project sponsors will determine which DTS/DAS/etc. methods have the highest priority.
2. Case studies will be carried our based on sponsor data.
3. Sponsor staff training in the use of the software will be provided.
4. The option of a 2nd phase for full commercialisation of the software will be offered.
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## Sponsor Suggestions

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Priority to ongoing and proposed projects agreed

JIP Review Seminar planned for Petrobras Autumn 2015

Further Sponsor suggestions Project {11} welcome
VAWE 2014-16 Project Meeting Schedule

- 26th – 27th March 2014
- 22nd – 23rd October 2014
- 22nd – 23rd April 2015 (Enterprise Seminar Room)
- 14th – 15th October 2015 (Tom Patten Meeting Room/ Enterprise Boardroom)
- 20th – 21st April 2016 (Tom Patten Meeting Room)
- 19th – 20th October 2016 (Tom Patten Meeting Room)

Any Other Business?
Lunch