ARTIFICIAL LIFT DESIGN & PRODUCTION OPTIMISATION Course

Provisional Detailed Course Contents

Monday (Gas Lift Design A)

Morning (08:30 – 12:30)

Introductions – venue / instructor / attendees / course overview

1. Introduction to Gas Lift
    a. How Gas Lift Works
        i. Basic System Components
        ii. Basic Gas Lift Equipment
        iii. The unloading process
        iv. Continuous operation
        v. Production performance variability
        vi. Comparison with other artificial lift technologies
    b. Valve Opening Equations
    c. Production Pressure Effect and R values
    d. Valve Closing Equations
    e. Spread

2. Working with Gas
    a. Using PROSPER, build a model of a gas lift gas supply line for a subsea well and use this to examine PVT relationships for gas and their impact on flow line pressure loss
        i. Derivation of Gas Deviation Factor using compositional analysis, charts and pseudo reduced pressures & temperatures vs. PROSPER PVT module

Afternoon (13:30 – 17:30)

3. Conceptual Gas Lift Design
    a. Well Performance Modelling
        a. Open a pre-built natural flow oil well PROSPER model and use this to examine the impact of gas lift.
        b. Phase Behaviour of Hydrocarbon Fluids
            i. General Description of Black Oil, Dry Gas, Condensate etc.
            ii. Black Oil Models
                1. use of Standing Charts to get PVT parameters
                2. tuning of standard PVT correlations to match lab data
                3. importance of viscosity data at lower temperatures
            iii. Selection of the right PVT parameters for well performance modelling (single flash vs. differential vs. multi-stage separator tests)
            iv. Importance of correct water gravity
            v. Difference between separator gas and gas lift gas PVT properties
        c. Examine life of well the natural flow production performance using:
            a. Sensitivity to Reservoir Pressure
            b. Sensitivity to Water Cut
        d. Examine impact of Gas Lift
            i. Gas Lift Input Data
                a. Gas Gravity
                b. Fixed Depth of Injection
                c. Optimal Depth of Injection
                    i. Gas Gravity
                    ii. Casing Pressure
                    iii. DP across valve

- d. Valve depths specified
- e. Safety Equipment

ii. Output Data Sensitivity Analysis (Life of Well Issues)

- a. Optimal Gas Injection Rate
- b. Max Depth & Range of Depths of Injection achievable in different circumstances
- c. Casing Pressure required for stable max depth of injection.

Tuesday (Gas Lift Design B)

Morning (08:30 – 12:30)

4. Detailed Gas Lift Design
   - a. 3 Basic rules
     - i. Never risk being unable to unload from the top mandrel
     - ii. You only have one opportunity to space mandrels
     - iii. Operation pressures rarely match design pressures
   - b. Overview of alternative Design techniques
     - i. Brief Review of Design Literature.
     - ii. API Documents
       1. Spec 11V1; RPs 11V2,5,6,7 & 8
       2. API Vocational Training Manual
     - iii. "Technology of Artificial Lift" by Kermit Brown
     - iv. SPE Petroleum Engineer's Handbook
5. Step by Step Graphical Design
   - a. Gathering the required data
     - i. Tubing Head Pressure – is it fixed?
     - ii. Casing Head Pressure – what value?
     - iii. Gas Lift Gas Gravity
     - iv. Gas Lift Gas Injection gradient
     - v. Load Fluid Gradient
     - vi. Shut-in Reservoir Pressure
     - vii. Production Pressure gradient –which one?
     - viii. Temperature gradients
     - ix. Design Safety Factors
   - b. Progress the Design
     - i. Determine Mandrel Depth
     - ii. Size the valve port
     - iii. Set the dome pressure
     - iv. Set the TRO pressure
     - v. Determine the next mandrel depth etc.
6. Compare Graphical Design with Software Design
   - a. Using Conceptual Design well model, progress to Detailed Gas Lift Design within PROSPER
   - b. Examine PROSPER Valve Design Options
   - c. Complete valve specification and compare with hand calculations
   - d. Examine sensitivity of the design to changed production conditions using "Quicklook for Gaslift" within PROSPER.
   - e. Enter Graphical Design output into PROSPER, and examine sensitivity of the design to changed production conditions using "Quicklook for Gaslift" within PROSPER.

Afternoon (13:30 – 17:30)

7. Gas Lift Optimisation & Troubleshooting
   - a. Production Monitoring
     - i. Network & Subsea Gas Lift Well Optimisation

        ii. Gas Injection distribution system pressure losses
        iii. Common flowline pressure losses (Tree pressure not fixed)
        iv. Well Testing
    b. Flowing Gradient Surveys
        i. Simultaneous Well Testing
        ii. "Anti-blowup" gradient survey tools
    c. Troubleshooting case study
    d. Distributed Temperature Sensing
    e. Tubing & Annulus PDHG

8. Gas Lift Well Integrity & Alternative Gas Lift Equipment
    a. Casing Design
        i. ID
        ii. Thread seal
        iii. Collapse rating & wear down-rating
        iv. Top of cement
    b. Wellhead Design
        i. Casing & Tubing Hanger thread and seal
        ii. Gas lift point of entry & ESD valve location
    c. Tubing Equipment
        i. Basic Equipment
            1. Valve (Injection pressure operated)
            2. Mandrel
            3. Kick-over tools
            4. Annular Safety Valve / VR plug valves
        ii. Optional Equipment
            1. Alternative Valve types & purposes
                a. Alternative configurations
                b. Spring valves
                c. High Pressure Valves
                d. Electric Valves
            2. Equalising dummies
            3. Annulus Pressure PDHG / DTS
    d. Retro-fit Gas lift equipment
        i. Punched holes
        ii. Straddle arrangements
    e. Construction Monitoring
        i. Well Integrity Management
        ii. MAASP
        iii. Modern Echometer technology

Wednesday (ESP Design A)

Morning (08:30 – 12:30)

Introductions – venue / instructor / attendees / course overview

1. ESP performance fundamentals;
    a. head generation & dependencies
    b. impeller types and characteristics
    c. use of pump performance curves
    d. conversion of head to pressure with density
    e. pressure gradient plots
    f. practical *workshop session*; hand calculations on head/pressure conversion, fluid levels and pump performance
    g. hand calculations using pump performance curves

Afternoon (13:30 – 17:30)

2. ESP system design & diagnosis
    a. ESP design review and integrated system (hydraulic, mechanical, electrical) issues & solutions
    b. practical workshop session; hand calculations of ESP design parameters (TDH, Qav) and sensitivities
    c. ESP design with software: PROSPER example

d. ESP system monitoring systems; surface and downhole measurements (historical and modern)
e. use of measured data in ESP diagnosis; electrical and hydraulic parameters; running amps & pressures
f. hydraulic (pressure) diagnostic principles; use for data validation and pump performance analysis
g. practical workshop session; practical applications of pressure diagnosis; validation of PI, PR, WC, Q etc.

Thursday (ESP Design B)

Morning (08:30 – 12:30)

3. ESP system diagnosis, troubleshooting & optimisation workshop
    a. linking amp chart and pressure responses; main dependencies and uses; affinity laws
    b. introduction to electrical system calculations; energy balance (hydraulic/electrical) interactions and uses
    c. review of electrical (amp chart) interpretation techniques; limitations and practical applications
    d. influences on ESP design (temperature, sand, scale etc.); runlife/reliability problems and solutions
    e. production optimisation; operator expectations and drivers; production rate vs. runlife issues
    f. whole system considerations; reservoir, well and surface facilities issues; practical solutions
    g. practical workshop session; diagnosis and evaluation of field examples
    h. use of electrical and hydraulic variables for ESP control and optimisation

Afternoon (13:30 – 17:30)

4. ESP operations best practices
    a. practical workshop session; recap of fluid levels & pressures and application to ESP design/diagnosis
    b. review of design, installation and operations best practices and procedures; use of incentive contracts
    c. final review of practical troubleshooting and diagnostic techniques
    d. ESP diagnosis team PROBLEMS; review and presentations
    e. team EXERCISE (field diagnosis of an ESP problem)

5. Hydraulic Submersible Pumps (Weir/Clydepumps)

    a. Comparison with ESP

    b. Applications

    c. HSP in PROSPER

Note: Each day will include practical workshop sessions illustrating the application of theory to well and ESP models. Participants are encouraged to bring field data and examples to interpret and analyse.

Friday (Jet Pump & Other Lift Technologies)

Morning (08:30-12:30)

1. Jet Pumps

a. Theory & Design

b. Applications

c. Jet Pumps in PROSPER

Afternoon (13:30 – 17:30)

2. Other Pumps

   a. Hydraulic Piston Pumps

   b. Rod Pumps

   c. Progressive Cavity Pumps

3. Gas Well De-liquifaction

   a. Intermittent Gas Lift / Plunger Lift / Continuous Gas Circulation

   b. Soap

   c. Velocity Strings

4. Award of Certificates / Opportunity for Feedback

END OF COURSE