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Moving the Frontiers in Artificial Lift Technology in Mature Field Operations

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Agenda

• Introduction
• Challenges in mature field operations
• Examples of smart technical solutions
• Intelligent material selection
• Economic evaluation
• Conclusion
Introduction

• Mature field operations will become an increasingly important theme for the future.
• Everyone in the E&P Industry will be faced with the challenges of delivering highest possible recovery factors in difficult environments.
• No single simple solution will solve the problems
• A basket of mutual supportive technologies is necessary
Challenges in Mature Field Operations

• Small margins and limited budget
• Production decline in tail-end phase = economic Constraints
• High water cut = high lifting & water treatment costs
• Corrosion (high water cut with CO₂) = short meantime between failures & loss of integrity
• Erosion (sand production) = short meantime between failures & loss of integrity
Principle: Making the Most of What You Have
Guideline: Reduce remedial workovers to free more budget for production enhancement measures

• Smart Technology
  • Advanced draw-down control
  • Electronic Rod Rotator

• Intelligent Material Selection
  • Corrosion Control
  • Sand Control
  • Abrasion Control
    • Poly-lined Tubing
    • Sinker Bars
    • Spray-metal Couplings
SELECTION OF SMART TECHNICAL SOLUTIONS
Continuous Fluid Level Measurement

• Based on radar technology
• Fluid level identification by signal pattern analysis (including frequency analysis)
• Easy to install at the wellhead without workover
• Relative accuracy of measurement +/- 3 meter (10 ft) (at one minute intervals)
• Very effective in combination with Variable Speed Drives
Fluid Level Measurement, Production Optimisation

- Prevents pumps from running dry → increases run life
- Pumps operated safely with maximum possible draw-down
- Accelerated production
- Increased ultimate recovery

Response on change of ESP speed

![Graph showing VSD Frequency and Measured fluid level over time.](image)
Further Applications

- Reservoir Engineering
  - Pressure build-up survey

- Production Operations
  - Condition monitoring of downhole equipment using noise pattern
  - Detection of abnormal conditions with frequency analysis (valve malfunction, tubing leak, rod buckling, etc.)
Electronically Controlled Rod Rotator

• Measures load and assures rod rotation when side wall force due to buckling is minimum

• Rotates only when necessary, thus minimizing number of rotations

• Thus reduces wear on tubing and rods
INTELLIGENT MATERIAL SELECTION
Corrosion Inhibitor Selection & Implementation

**Problem**
- Corrosion, high water-cut with CO₂ in production operations

**Field Data**
- Produced media
- Materials in use
- Flow conditions

**Candidate Selection**
- Input field data
- 3-4 Products by service companies
- Pricing and dosage

**Screening Testing**
- Verify performance with lab tests (up to 10 test runs)

**Final Testing**
- Field test in actual environment

**Final selection**
- Based on commercial and operational results, product, cost, dosage
Corrosion Rate Survey Results (Field)

**Water Cut:** 97%

**CO₂ Concentration** up to 10%

**Time to result:** 3 – 4 Months per Well

**Corrosion Rate** < 0.005 mm/yr (0.02 mpy)

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**Zero Measure**

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**CORROSION [mm/yr]**
Erosion Control with Ceramic Sandscreens

- Unique material properties of SiC
  - Utmost resistance against erosion
  - Highly corrosion resistance
  - Lower density compared with steel (less weight)
  - Heat resistant up to 1800°C
  - High hardness
  - High stiffness

Stack of ceramic rings
Sand Screen for a North Sea Gas Producer

- The well was closed in since 1997 due to significant sand production
- Sand screen landed in nipple below production packer
- Set on production on February 2011, flowing well head pressure of 850 psi, gas rate of 6 MM scf/d, sand free, still producing with 2 MM scf/d with lower flowing pressure than ever
Reduction of Wear with Coated Sinker Bars

• Sinker Bars weigh the lower part of the rod string directly above the pump (more tension during „down stroke“). Buckling and Friction is thus minimised.

• Specially designed „super fine surface finish“ metal film on flexible centralisers, which further smoothen surface and reduces the loss of material

• The metal film is also used for couplings of the rod string.
Sinker Bars with Super Fine Finish Coating
Reduction of Wear with Specially Developed Polylined Tubing

Modified HDPE – Temperature up to 95° C

• Advantages:
  • Less paraffin precipitation due to better heat insulation
  • Less tendency for depositions due to smooth surface
  • Less abrasion due to less friction
  • Energy savings due to less friction (10 to 15%)
  • Re-use of used tubing
## Poly-Lined Tubing

**Comparison of EU J 55 with HDPE Liner**

- **Status**: 14 06 2013
- **Installed since**: 2006-03-07
- **Polylined Tubing from**: 446 - 889 m
- **Additional Investment**: $ 4,000
- **Savings**: ca. 25 Workovers: $ 1,000,000
- **Average Meantime between Failure J 55 Plain**: 102 days

<table>
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<th>Days</th>
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<td>Average Meantime between Failure J 55 Plain: 102 days</td>
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</tbody>
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ECONOMIC EVALUATION
Case Study: Operation Centre Zistersdorf

- Two fields in Operation since 1937
- Complex Geology along the major „Steinberg“ Fault
  - Numerous small fractures
  - Many unconsolidated formations
- Hydrocarbon bearing more than 1000m in „Neogen“
- 62 wells (of which 30 in production)
- Up to 10% CO2 in associated gas
- High Water Cut (ca. 95%)
Significant Increase of Equipment Lifetime with a Reduction of Repair Workovers

- 2005
  190 failures per 100 active wells

- 2012
  9 failures per 100 active wells

Theoretical time between failures 11.1 years
Significant Increase of Equipment Lifetime with a Reduction of Repair Workovers

Failure Statistics

MTBF = mean time between failure

MTBF 1 Yr.

MTBF 2 Yr.

MTBF 5 Yr.
Production Results until 2011

Metric Tons

-6.8%
+2.5%
-4.9%
4% 2006-2011
Production Forecast

- Case 1: Business as usual = Production decline 6.8%
- Case 2: Technology Implementation = Production decline 4%
Revenue vs. Expenditure 6.8% (base) vs 4%
Marginal Cost Analysis (6.8% versus 4% Decline)

Comparison Revenue vs. Expenditure

- Revenue 4%
- Expenditure 4%
- Revenue 6.8%
- Expenditure 6.8%

Assumptions:
- Oil Price + 2.5%/y
- OPEX + 2.5%/y

end of economic production 2009 (6.8%)
end of economic production 2023 (4%)
Conclusion: The Way to Success

• Challenge: Limited expectation of field lifetime

• Approach: Building a ‘Mature Field’ Competence Team to develop new solutions

• Process:
  • 1. Analysis of available technologies along the production chain
  • 2. Identification of advanced materials with exceptional lifetime in tough production environments
  • 3. Development of a stringent selection process for corrosion inhibition

• Results: Development of new technologies ‘fit for purpose’, modifications of existing technologies, use of new materials.
The value of an idea lies in the using of it.
Thomas A. Edison

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