Field Development Planning Using a Surface to Subsurface Model – ALS selection

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Pemex
Overview

- In reservoir development, selection and implementation of artificial lift is one of the key issues which must be considered when planning for the lifetime of the reservoir.

- It is common practice to implement artificial lift once the wells’ production declines significantly (or ceases) due to decreasing reservoir pressure or increasing water cut.

- Selection of the artificial lift system is often performed for that period of time, and normally is based only on the resulting increase in production rather than on a global technical-economic evaluation.
Overview

- In this study, an integrated model of a field exploitation project for an offshore asset was built. The resulting surface-to-subsurface model includes a material balance model (reservoir), nodal analysis models (wells), and a network model (surface facilities).

- The integrated model was tuned to measured/historical data and used to run production forecasts. These forecasts provided a schedule of reservoir pressures, oil, gas and water rates versus time. With this information, based on operational constraints defined by the asset, several key operational decisions were evaluated.

- These included the optimal time to implement an artificial lift system as well as the selection of the most appropriate form(s) of artificial lift as a function of reservoir life cycle. Two artificial lift methods (gas lift and ESP) were pre-selected based on technical screening criteria. These were evaluated relative to their NPV and Np values for each particular system. Field results of this work are presented in this paper.
Gas Lift Variables

- Continuous flow gas lift is a widely accepted process that has several variables to be taken into account. Some of the most important are:
  - Casing Pressure
  - Orifice size
  - Injection Rate
  - Depth
  - Well Head Pressure
  - GOR
  - etc
Relationship between CHP and Qgi

Requires Gas-lift Valve Modelling

- Ptub at operating valve
- Increasing CHP
- Valve
- Tubing

Gas Injection Rate vs. CHP

Feb. 4 - 8, 2008
2008 Gas Lift Workshop
One well with high casing pressure can force the system to operate at a higher than optimum GL header pressure – Energy being wasted in other wells through the automatic gas injection chokes.
Effect of Gas Lift Header Pressure

- Gas Lift header pressure should be optimized based on overall field requirement, considering the gas lift operating efficiency of wells.

Higher gas Injection Pressure may be Required to lift wells deeper.

Gas Injection Pressure reduced by running GLV with proper port Size at Operating depth.
Gas Lift Variables

- Most of these variables are been considered and are taken as main variables or used as sensitivities when a design is required.
- Also many studies for gas lift design, implementation, monitoring, etc have been done in the past and will continue in the future.
- Most of the time, these studies consider two main facts:
  - Include and study the well by itself.
  - Designs are done for a specific point in time, that could be when:
    - There is no flow
    - Increase of %wc
Gas Lift Variables

• There are implications when this approach is followed:
  – Individual gas lift optimization of a well, doesn’t necessarily mean optimal operational conditions of the well for the total production system.
  – Definition of time to implement ALS might not be optimal.
• To accomplish a better exploitation of a field, it is necessary to include other variables in the decision to define what ALS is the better option and when is the best time to implement.
• Planning of the ALS implementation taking into account the whole life of the reservoir is the approach that will be presented in this work. It is necessary to have an integrated S2S model to run different scenarios to select the optimal method.
Integrated modeling S2S

- Few studies of integrated S2S modeling have been done until now.
- Most of these studies use commercial software and excel spreadsheets, making it difficult to update the models.
- New tools in the market make viable the integrated modeling without requiring long periods of time for results.
- This integrated model is the basis for the study of the implementation of an ALS, in Pemex fields.

Fig. 2—Production-system-analysis approach: dynamic RIPM method.
Integral S2S Model

Production Forecast

Material Balance

Well Model

Surface Network

Feb. 4 - 8, 2008

2008 Gas Lift Workshop
Case Study - Objective

• Present the methodology used for ALS selection, taking into account an integrated S2S model and the values of Np and NPV that result for each ALS.
Field Description

Study Area:: Litoral de Tabasco Asset (AILT)

18 Fields

- 7 Black Oil
- 7 Volatile Oil
- 4 Condensed Gas

- Carbonates, Naturally Fractured open sea depositional environment (Formation Cretaceous, K)

- Och – Uech – Kax Fields
- Ayin – Alux – Yaxche Fields
- Light Marine Oil (Bolontiku, Citam, Costero, Kab, May, Misón, Sinan y Yum

- All Wells are Natural Flowing (NF)
Process Description

Optimal selection of Artificial Lift System in Sinan, Alux, Yaxche, Ayin, Misón and Bolnytiku Fields

**Phase 1:**
- Material balance calculations
  - Pseudo Kr curves
- Wells Modeling
- Surface Installation Modeling
- Integration of the model S2S
- History Match and Forecasting
Process Description

- **Phase 2:**
  - **Optimal Artificial Lift System Selection in Sinan, Alux, Yaxche, Ayin, Misón and Bolontiku Fields.**
    - Selection of time implementation, based on operational constraints
    - Run scenarios and calculate production profile and Np for each field.
    - Economic evaluation, with operational constraints.
    - Selection of ALS, based on Np, NPV values.
Optimal Artificial Lift System Selection in Sinan, Alux, Yaxche, Ayin, Misón and Bolontiku Fields.

1. Field Pressure Trend (Pws).
2. Fluid Behavior curve (oil, gas, water).
3. Well Pressure Trend (BHP, THP, Drawdown).
4. Productivity Index (PI) Behavior due to changes in field conditions such as static pressure, pseudo Kr, aquifer influx.
5. Design GL and ESP wells.
Results Material Balance

Forecast based on Material Balance Calculations
e.g. Uech Field.

<table>
<thead>
<tr>
<th>Cases</th>
<th>2P</th>
<th>BM</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
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History Match

BM

N = 165.11 MMBN of Oil
**Technical Evaluation - Results**

**CAMPOS SINAN AREA 201**

**POZO 257**

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<th>Método</th>
<th>PWS</th>
<th>BHP</th>
<th>Drawdown</th>
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<th>$Q_{total}$</th>
<th>Diámetro de Aparejo</th>
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<td>kg/cm²</td>
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<td>BPD</td>
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Initial DRAWDOWN 54.8 KG/CM² (968 psi)
Results Surface Evaluation
Detailed diagram well-surface facilities.

Infraestructura de Explotación de los Proyectos del Activo Integral Litoral de Tabasco

Abk D model with AILT production on first Stage.
Results of Surface Evaluation

c) Evaluating handling the ASSET production until 2020

Oil increase and comparison with all cases evaluated
Results

Optimal Artificial Lift Method selection in Sinan, Alux, Yaxche, Ayin, Misón and Bolontiku Fields

Mison Field Example

Well Misón 101

A: Date in which Artificial Lift Method is needed

B: Optimal Starting point/Evaluation according to premises
Results

Optimal Artificial Lift Method selection in Sinan, Alux, Yaxche, Ayin, Misón and Bolontiku Fields

Mison Field Example
Well Misón 101

GLV Spacing

Comparative plot with 3.5” tubing and 4.5” tubing
Sensitivity to Injection Gas

Feb. 4 - 8, 2008
2008 Gas Lift Workshop
22
### Technical Evaluation - Results

**CAMPO MISON. POZO MISON 101**

<table>
<thead>
<tr>
<th>Método</th>
<th>PWS</th>
<th>BHP</th>
<th>Drawdown</th>
<th>Q₀</th>
<th>Q_total</th>
<th>Diámetro de Aparejo</th>
<th>Gas de Inyección</th>
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<td>kg/cm²</td>
<td>kg/cm²</td>
<td>kg/cm²</td>
<td>BPD</td>
<td>BPD</td>
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<td>2633</td>
<td>2674</td>
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- Recommended tubing diameter: 4.5”
- Optimal gas injection rates for 3.5” and 4.5” tubing are 1.0 MMSCFD and 2.5 MMSCFD respectively
- BEC represents greater savings for these conditions without surpassing initial drawdown of 472.71 kg/cm² (6278 psi)
COMPORTAMIENTO DE PRODUCCION ACUMULADA CAMPO SINAN AREA 101
COMPARACION BN, BEC, FN

PERFIL DE PRODUCCION CAMPO SINAN AREA 101
COMPARACION FN, BEC, BN

CAMPO SINAN AREA 101

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CAMPO SINAN AREA 101

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### Economic Indicators – NPV

#### Gas Lift

<table>
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<th>Sinan area 101 with Compression and Separation Platform</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
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<td>Np Production (BBLs)</td>
<td>47,760</td>
<td>430,640</td>
<td>853,300</td>
<td>1,196,700</td>
<td>1,292,700</td>
<td>1,398,100</td>
<td>1,454,500</td>
<td>1,517,300</td>
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<td>Gas Production (MMpc)</td>
<td>21</td>
<td>189</td>
<td>374</td>
<td>871</td>
<td>1,005</td>
<td>994</td>
<td>955</td>
<td>924</td>
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<td>Income ($)</td>
<td>1,147,400</td>
<td>10,345,868</td>
<td>20,499,738</td>
<td>28,750,362</td>
<td>31,055,998</td>
<td>33,588,386</td>
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<td>Investments ($)</td>
<td>1,112,610</td>
<td>6,286,369</td>
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<td>Net Present Value (NPV)</td>
<td>-249,497</td>
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<td>4,012,604</td>
<td>9,396,898</td>
<td>9,657,109</td>
<td>11,968,286</td>
<td>10,659,466</td>
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<table>
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<tbody>
<tr>
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<td>2,643,200</td>
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<td>1,526,600</td>
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<td>Gas Production (MMpc)</td>
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<td>1,292</td>
<td>1,160</td>
<td>1,042</td>
<td>954</td>
<td>880</td>
<td>812</td>
<td>747</td>
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<tr>
<td>Income ($)</td>
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<td>63,501,032</td>
<td>56,985,892</td>
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<tr>
<td>Investments ($)</td>
<td>3,444,083</td>
<td>5,245,666</td>
<td>3,444,083</td>
<td>5,245,666</td>
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<td>5,245,666</td>
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<td>Net Present Value (NPV)</td>
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<td>5,822,218</td>
<td>4,444,997</td>
<td>3,861,284</td>
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NPV: 138,717,397
COMPORTAMIENTO DE PRODUCCION ACUMULADA CAMPO MISON
COMPARACION FN, BEC, BN

PERFIL DE PRODUCCION CAMPO MISON
COMPARACION FN, BEC, BN

CAMPO MISON
Metodo | Produccion Acumulada (MMSTB)
--- | ---
FN | 58.88
BN | 82.75
BEC | 87.33

METODO | FECHA
--- | ---
FN | pr-20
BN | Jul-26
BEC | Jul-26

CAMPO MISON
Metodo | Produccion Diaria (BPD) |
--- | --- |
FN | 3032 |
BN | 4332 |
BEC | 4657 |

FECHA | BPD |
--- | --- |
Apr-20 | 3032 |
Jul-26 | 4332 |
Jul-26 | 4657 |
Economic Indicators

![Bar chart showing VPN (MMUSD) for different locations: Sinan 101, Sinan 201, Mison, Ayin, Yaxche, Bolontiku. The chart includes categories for BNA, BN OTROS, BEC 1, and BEC 2.]
Economic Indicators

Años

Tiempo de Pago

Sinan 101  Sinan 201  Yaxche  Bolontiku  Ayin  Mison

Economic Indicators

- Sinan 101
- Sinan 201
- Yaxche
- Bolontiku
- Ayin
- Mison

Legend:
- BNA
- BEC 1
- BEC 2
- BN Otros
Using an integrated methodology - [Reservoir (MB) – Well Modeling (IPR) - Surface Modelling (Gathering System)] is a must when evaluating opportunities in reservoir exploitation behavior.

Using relative permeability pseudo curves allows to adjust the starting point of a well or group of wells for production forecast, as well as adjusting fractional flow.

An increase in reserves recovery can be achieved by optimal artificial lift method selection in evaluated fields (Sinan K, Bolontiku, Yaxche, Ayin, Misón), 29.3% if GL is chosen and up to an additional 8% if ESP is applied when compared to Base Case (Natural Flow).

For Sinan, Bolontiku, Ayin and Misón, the best option is Cont. GL; and for Yaxche field it is ESP.
Thanks for your Attention
Evaluated Scenarios

Schematic of autogenous GL

TMDB