Optimum Well Design for Marginal Offshore Oil Field Development

A case study comparing conventional, non-intelligent well completion and SMART/Intelligent well completion design

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Highlights

- Background
- Integrated Workflow for Life-Cycle Evaluation
- Production Optimisation with Smart Completion
- Sand Production Risk Mitigation
- Water Production Risk Mitigation
- Reservoir Pressure Management
- Conclusions
Introduction

• Appropriate amount of frontend loading to identify the most optimum field development concept and well design technology is key for maximising project values and long-term field development.
Case Study Background

- Marginal offshore oilfield development in ~15 m water depth
- Minimal well count for developing laminated oil reservoir layers in faulted structures
- Relatively high pressured reservoirs with 1 – 2% CO2
- Production tie-back to nearby brownfield processing platform 6 km away
- Potential pipeline flow assurance issue
- Requirement of artificial lift to sustain well production
- Requirement of well and reservoir surveillance and management
Well Design Background

- 3-1/2 dual-string non-smart (conventional) completion design was initially selected for maximizing oil production

- Well completion design is being revisited to assess merits of smart completion:
  - Better well & reservoir surveillance and management (with downhole gauges & valves for high frequency real-time monitoring and optimization)
  - Well costs optimization (slimmer hole with single string)
  - Topside costs optimization (less flowlines with single string)
  - Less OPEX cost (less well interventions, less SCSSVs to service, less flowline equipment and instrumentations to maintain)
  - HSE aspects (less drilling cutting disposal, less operator intervention with remote monitoring and operation via downhole gauge and valve)
Integrated Workflow for Life-cycle Evaluation

- Integrated production model (IPM) used for life-cycle evaluation for completion concept select (tubing size, dual-string vs single-string, conventional vs Smart)

**Reservoir Parameters**
- Pressure
- Temperature
- Rock properties
- PVT

**Well Parameters**
- Trajectory
- Tubing size
- ICVs

**Facilities Parameters**
- Surface piping/pipeline dimensions
- Flowline choke size
- Landing pressure

- **Production Profiles**
  - Pressure
  - Oil
  - Water
  - Gas

- **Surveillance & Optimisation Frequency**
  - Conventional (Non-smart)
  - Smart completion

- **Tubing Size Sensitivity**
  - 2-7/8”
  - 3-1/2”
  - 4-1/2”
  - 5-1/2”

- **Completion Concept**
  - Dual String
  - Single String

- **Life Cycle Evaluation**

- **Project Life Cost**
  - CAPEX
  - OPEX
Well Production Profile – Dual String versus Single String

- For non-smart completion and uncommingled reservoirs case, the selection of single-string design (2 well strings) over dual-string design (4 well strings) will cause significant production deferment during the initial well life but no significant impact to ultimate recovery (EUR)

- With smart completion (ICV/PDG) and well drawdown optimization between the co-mingled zones, comparable well production to dual-string design can be achieved
Sand Production Mitigation – Zonal Drawdown Control

- Conventional completion (SSD) gives sub-optimal drawdowns across the reservoir layers as production choking is done indiscreetly from surface choke
- Smart completion (ICV/PDG) can individually optimize well zonal drawdown to give most favourable drawdowns across all layers for maximizing oil production

**Critical Drawdown Limit (sand control)**

**Low frequency drawdown control**

**High frequency drawdown control**

**Note:**
- Zone 1 and Zone 4 are found to be needing ICV opening optimization most
Water Production Mitigation with Smart Completion

- Sensitivity of premature water breakthrough in the middle zone 2 (well completion being closer to water contact) and the effect of ICV choking optimization suggests that water production can be minimized while maintaining oil production.

Note:
- Watercut sensitivity range of 5 – 30% investigated (for moderate aquifer support)

Total well ICVs optimization suppress production from watered out zone 2 while increasing choke opening for more production from zone 4.
Water Production Mitigation with Smart Completion

- Production optimization with PDG/ICVs can effectively minimize water production from watered zone while still maximizing total field oil production.

- The values of having smart completion is more evident for the case of premature water breakthrough whereby ICVs works actively to delay water production at downhole zone, conventional completion is shown to be less effective in mitigating this risk.
Reservoir Pressure Management

- Gradual reservoir pressure depletion management can be effectively achieved with smart completion (PDG/ICVs)
Conclusions

• An optimum well design is found for an offshore marginal oilfield by performing total life-cycle value assessment

• Single-string with smart completion design can provide significant production optimization (minimizing production deferment) to give comparable production profile compared to dual-string conventional completion design.

• Smart completion (PDG/ICVs) can mitigate downside risk of premature water production while still maintaining oil production more effectively when compared to conventional non-smart completion.

• Remote monitoring (via PDGs) is crucial for operating well within safe drawdown limit, conventional completion design limits effective drawdown monitoring as data collection needs well services resource (wireline unit, wireline engineers) with logistic constraints (wireline unit availability – once a month?).