Operational Flow Assurance – Effective use of OLGA for Replicating and Managing Slugging Systems in Late Field Life Assets

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• Key Model Inputs
• The ‘late-life asset’ approach
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The Problem

Asset Info & Design Considerations

• Asset located offshore in cold waters of 5 – 7degC and 110m water depth
• Original design was for circa 12,000bbl/d production
• Initial design was very robust and considered normal steady state and transient operations including slugging operations
• Separator and outlet valves were sized accordingly and slugging not expected to be an issue.

Today....

• Production down to <1,500bbl/d for last 7 years
• Slugging is resulting in operational issues – trips and inability to ramp-up
• Well deliverability and reservoir potential is estimated to achieve 5 – 6kbpd so at least a 3.5kbpd production loss

The asset performance significantly reduced due to slugging behaviour resulting in separator tripping periodically and inability to ramp-up the well.
The Conventional Approach

Asset Info & Design Considerations

• Revisit the design models and slugging reports – This confirmed no slugging issues even at the low flowrates
• OLGA Models were revisited, and the model was extended to include full production system – wells, flowline, riser, separator and outlet valves.
• Normal operating conditions and ramp-up analysis was performed at current operating rates. No operational issues as the models predict stable, seamless ramp-up with liquid transients occurring but certainly no trips.
• Significant effort was then applied in trying to benchmark the model’s predicted slugging performance against what was observed.
• No success 😞!: 
  – liquid surge volume predicted were 0.2m³ what was measured (estimated) when separator trips was 3m³.
  – Slugging trends not even closely matches as no terrain slugging but high-frequency hydrodynamic slugging observed

The OLGA model used for design of the asset was simply unable to match the observed behaviour of the slugging trends and characteristics.
Key Model Inputs

- Detailed topography
- Subsea / well choke characteristics
- As-built subsea ‘plumbing’
- Full separator details
- Control valves sizes
- PCV and LCV controller inputs
- Well trajectory
- Reservoir inflow performance
- Spools, riser, etc.
- Fully integrated dynamic OLGA model including inflow performance, well, gas-injection, pipeline, spools, riser, separator and separator outlet valves/controllers.

- Model was utilised to simulate various operating scenarios as required by changing model inputs such as valve position, controller setpoints, gas-lift injection rates, pressure boundary conditions, etc.
The Late-Life Approach

Key Questions:

• How does the current operating condition deviate from design?
• What is the cause of the deviation?
• Does this introduce any change to the way the models are constructed?
• There could be several deviations from design conditions – what are the important factors that could so significantly impact the operability with respect to the problem at hand?
• Can these be modelled or somehow represented in a model?

The sequence of historical events that have so altered the production system performance from design needs to be identified. Then find out how these/this can be modelled.
The Late-Life Approach

Key Deviations from Design & Observations:

- Extensive data review – pressure, temperature, slugging characteristics over the last few years.
- The slugging was terrain induced! Periods of no-liquid flow observed. A surprise as this wasn’t expected nor picked-up at design stage.
- The pressure drop in the pipeline was increasing with time over the years.
- Depressurisation of the pipeline didn’t result in pressure equalization as quickly as expected.
- Operating temperature had been below WAT (wax appearance temperature) for the last 5 years.
- But wax inhibitor was injected, and the wax was an easy yielding wax.
- How does the current operating condition deviate from design?

The sequence of historical events that have so altered the production system performance from design needs to be identified. Then find out how these/these can be modelled.
The Late-Life Approach

Answer to the ‘late life’ Questions:

• Wax accumulation was occurring
• This wax resulting in build-up in the pipeline/riser
• The wax inhibitor was an anti-agglomerant but the pipeline had several shut-in periods over the last 5 years.
• The pipeline pressure steadily increased to circa 5 x what is expected so the flow was certainly not generating sufficient shear to remove or entrain the wax
• With each shutdown and slow depressurisation, precipitated wax will settle and compact with time

Low flowrate -> low temperatures and wax precipitation
Frequent shutdowns + Low Flowrate -> wax accumulation insufficient shear
Answer to the ‘late life’ Questions:

- The location of the wax was unknown – was this evenly distributed along the pipeline length or localized?
- The nature of the slugging and depressurisation trends suggested a localized constriction.
- But where was this localized constriction? – the slugging trends, the cyclical/terrain patterns indicated an elevated restriction that at the low flowrates will result in liquid accumulation upstream of the restriction which is then produced into the separator.
- This resulted in the pressure trips that were also observed in addition to the separator level trips.
- The result is a totally different system from design – the infrastructure has altered in a way that changed the operability / slugging significantly.

Slow depressurisation/pressure equalisation -> localised wax restriction

Terrain slugging -> restriction at elevated section likely riser-base
• The adjustment made is below. May not be exactly what exists but sure gives the observed behaviour and ties-up with the expected outcome from the system issues.
The Result...

- **Liquid & Gas Arrival Trends and Slug Volume**

 Slug trend close to what is observed

 Slug volume as observed!
Thought Process Followed

Starting Point is OPERATIONS DATA REVIEW

Identify Deviations from Design Expectations (Pressure drop, depressurisation data, temperature, slugging trends, etc)

Account for ALL historical Operations and identify factors – usually a chain of events, that can cause the deviations

MODEL CONSTRUCTION, BENCHMARKING & USE FOR ADDRESSING PROBLEM

Flow much less than design consideration

Operating Pressure much higher than what is expected at turndown

Accumulation of Wax

Slugging trends & depressurisation rate indicate type & location of wax accumulation

Used Model to evaluate the above rationale
Conclusion

• Late field life assets often deviate from design conditions and dynamic modelling performed to investigate operational issues need to account for this
• The starting point is not modelling but OPERATING DATA REVIEW
• Check parameters that will impact the variable of interest noting these parameters may indirectly affect the variable of interest
• Identify the potential causes for deviations from design – these could be theories
• Only then get to modelling even if this means revisiting and modifying design models
• Process adopted highlighted the mindset for late life assets operational flow assurance problem solving is working backwards from today’s operations to yesterday’s design
• Knowledge of the governing processes (wax deposition process and slugging patterns) and limitations of inhibition used (in this case wax inhibitor limitations)
• OLGA is much a late-life operations support tool as a design tool
Thank you

Questions...