

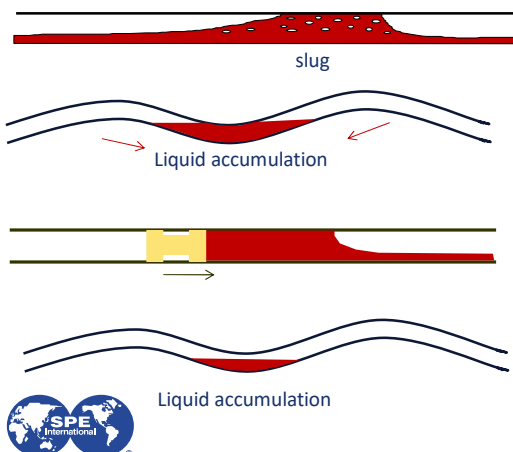


Active Slug Mitigation and Control for Reducing Emissions

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What is Slugging?



- **Hydrodynamic slugs:**
 - Conditions: slug flow regime
 - High frequent occurrences
 - Relatively small liquid volumes
- **Start-up slugs:**
 - Liquid accumulation in low spots during shut-in
 - Liquid is swept out when starting up
- **Pigging slug:**
 - Liquid surge caused by launching a pig
 - Large volumes
- **Terrain slugs:**
 - Low production + low spots: liquid accumulation
 - Flowline only: transient slugging
 - Flowline + riser → **riser induced slugging or severe slugging**

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Slug Mitigation and Control – Why is it Important?



More complex field development and operation

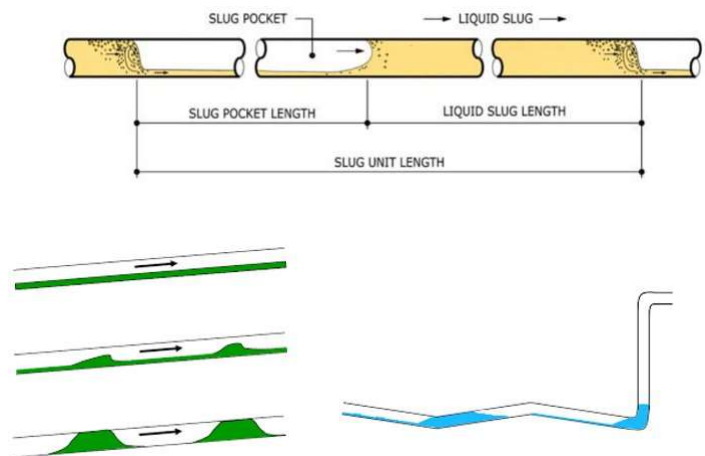
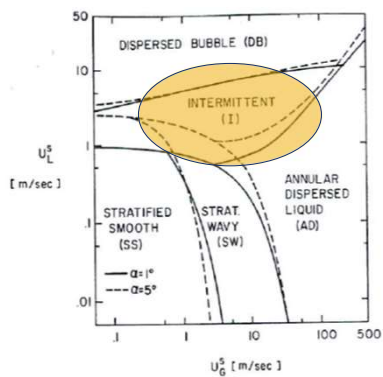
- Development of marginal and deepwater fields that tieback into existing facilities
- End of field life production optimization

Significant impact on performance bottom line

- Unreliable field operation with trips/shutdowns → Blowdown/Flaring
- Impact on equipment integrity
- Excessive Maintenance/ Field abandonment – Late Life



Slug Mitigation and Control – What is it about?



Slug Mitigation and Control – What are our Options?



Facility Design and System Configuration

- Building a large separator or slugcatcher
- Adopting slugging averse pipeline/riser design
- Incorporating riser-base gas-lift system
- Subsea Separation
- Subsea Pumping

Field Operation and Valve Control

- Operating outside of slug flow regime
- Manual topsides choking at separator inlet/riser top
- [Active slug control and Mitigation](#)
- [Gas Lift Optimization](#)



Active Slug Control – How does it work?

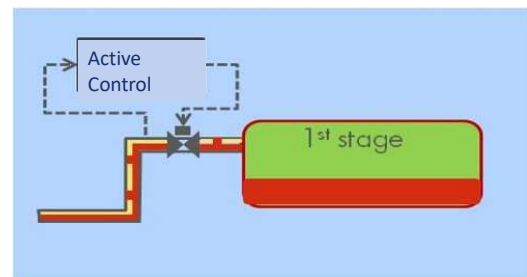


- **Required Data:**

- Pressure drop across valve
- Upstream pressure measurement
- Valve opening

- **Main functionalities:**

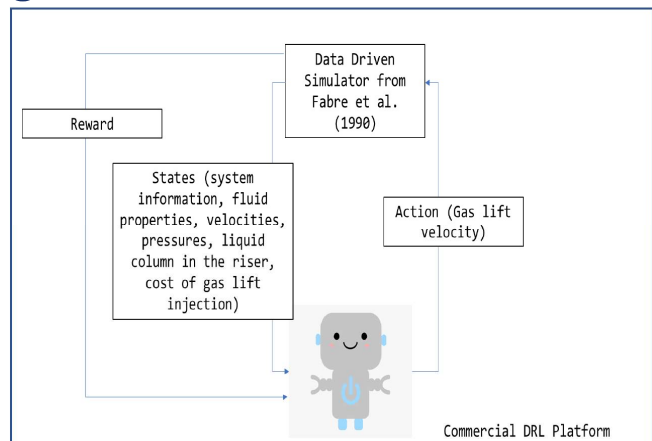
- Objective → maintain constant total volumetric flow
- Detect Phase → mixture, liquid or gas phase arriving at choke.
- Adjust Valve Opening → based on Phase



Gas lift optimization to mitigate severe slugging using Deep Reinforcement Learning



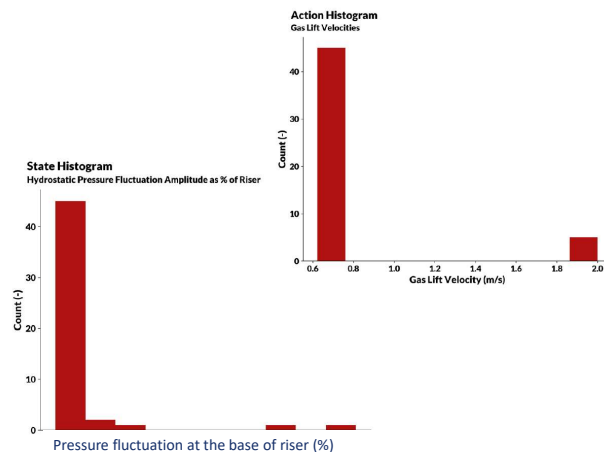
- Deep reinforcement learning agent makes decisions to support operators
 - Too many variables for human operators to track
- Control problem
 - Too much gas – frictional pressure drop, higher backpressure, higher compression costs
 - Too little gas – severe slugging



Gas lift optimization to mitigate severe slugging using Deep Reinforcement Learning



- Challenges:
 - Simulation and training environment
 - Fast simulation which captures accurate physics
 - DRL algorithm implementations
 - Reward functions
 - Minimize severe slugging
 - Minimize gas lift usage, when possible
- Results:
 - Test cases
 - Severe slugging mitigated in all cases
 - Gas lift usage reduced in all cases except edge cases where full gas lift injection was needed





QUESTIONS ?

