TEAM

F037

Smart Anti-Slug Pipeline: Chitosan-Based Internal Coating + Integrated One-Way Valve with Active Slug-Separation System

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CHE PETE 3 ISE

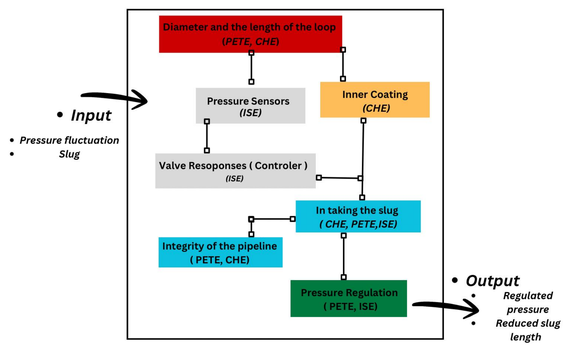
Introduction

An integrated anti-slug system is proposed to actively mitigate slug formation within pipelines. The design combines a smart inline control mechanism with a chitosan-based internal coating. This allows real-time detection and suppression of slugs before they develop further.

Problem Statement

Surface facilities are highly affected by slug flow, leading to pressure fluctuations and potential equipment damage. When slugs are only handled downstream, their impact becomes more severe. A proactive, in-line solution is needed to mitigate slugs before they escalate.

Deliverables



Constraints and Specifications

❑ CHE- Chemical Engineering

- Operating conditions: 70-100°C, 70-200 bar
- Coating adhesion strength ≥ 4 MPa
- ≥ 90% Chitosan coating composition
- Coating thickness 50-200 µm
- Slug length drop ≥5% (Coated vs Uncoated)
- Friction drop ≥5% (Coated vs Uncoated)

❑ PETE- Petroleum Engineering

- Lab testing T <50°C and P <2 bar
- Lab testing pipeline L<5m, ID=4inch
- No gas leakage at junction points
- System operates within −29°C to 427°C, and internal operating pressure <= MAOP
- ≥40% reduction in 1-in-1000 slug volume
- Applicability for wide range of slug lengths
- ≥30% reduction in downstream peak-to-peak pressure fluctuations vs. upstream

❑ ISE- Industrial & System Engineering

- Decision response delay ≤ 3s
- Average control activation frequency ≤ 3 activations/min
- Control decision response delay ≤ 3s after slug event
- ≥ 30% reduction in downstream pressure fluctuations
- Decision accuracy ≥ 95% for slug detection
- ≥ 20% reduction in control activations vs. baseline

❑ Integrated Specifications

- Backflow ≤ 1% during slug events
- ≥ 85% coating integrity (30 days)
- ≥ 20% reduction in maintenance downtime

Test and Validation

- **PETE-Petroleum Engineering**
- Successful operating with forward flow
- $A = \frac{P_{downstream}}{P_{upstream}} \leq 0.7 \quad A = \frac{16399.61}{24.602.32} = 0.6666$

- **CHE-Chemical Engineering**
- Coating Composition

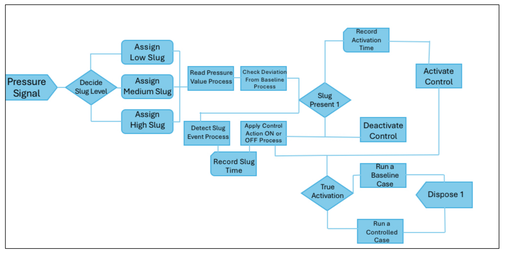
$$\%\text{Chitosan} = \frac{m_{\text{chitosan}}}{m_{\text{chitosan}} + m_{\text{PVA}}} \times 100 = \frac{9\ g}{9\ g + 1\ g} \times 100 = 90\%$$

- Slug length reduction

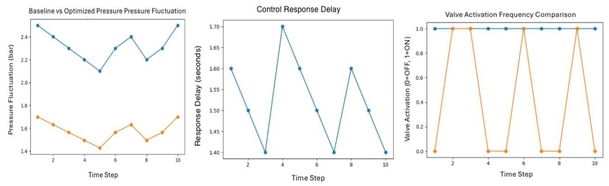
$$\%Reduction\ In\ Slug\ Length = \frac{slug\ length\ (base\ case) - slug\ length\ (with\ coating)}{slug\ length\ (base\ case)} \times 100$$

$$= \frac{7.137 - 6.721}{7.137} \times 100 = 5.83\%$$

- **ISE-Industrial & System Engineering**
- Simulation (used to evaluate system performance)

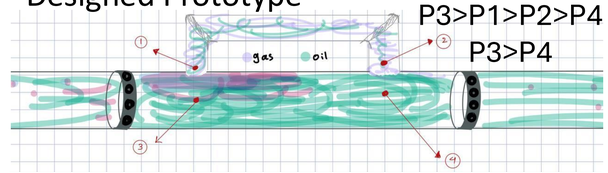


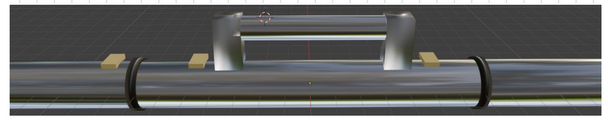
- **Power BI**



Prototype Design

Designed Prototype





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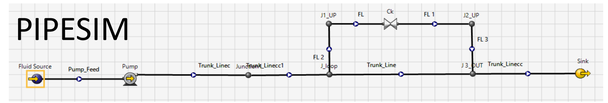

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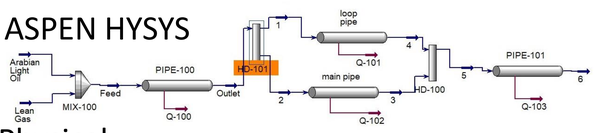

Physical

Conclusion

The system showed promising behavior in reducing pressure fluctuations and stabilizing flow under simulated conditions. Further modifications and design refinements particularly in control response and coating uniformity will support its transition toward field-scale application.