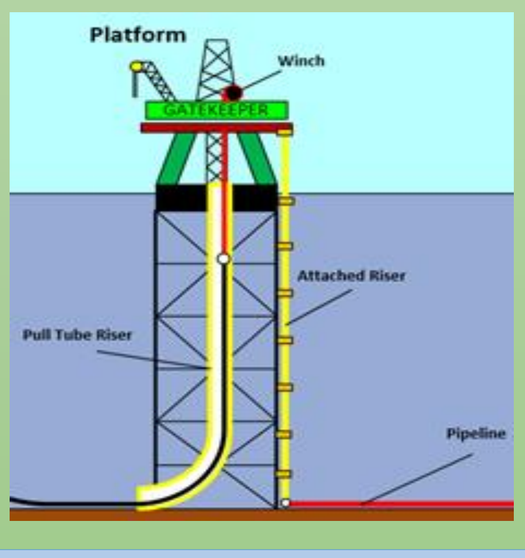
Investigation of Severe Slugging in Pipeline-Riser Systems

INTRODUCTION

Over time, oil and gas exploration and production has advanced into deeper waters in West Africa, the Gulf of Mexico and South America and continues to go deeper. The configuration of the pipeline-riser systems, which is used to transport the extracted hydrocarbon, often has the pipeline section inclined downwards. This configuration can potentially lead to flow instability known as severe slugging in the pipeline-riser system.



OBJECTIVES

1. To understand when/how severe slugging occurs in a multiphase pipeline-riser system.
2. To develop numerical models to simulate and predict severe slugging
3. To validate the numerical results with experiment data.
4. To evaluate the economic impact of severe slugging on production output.

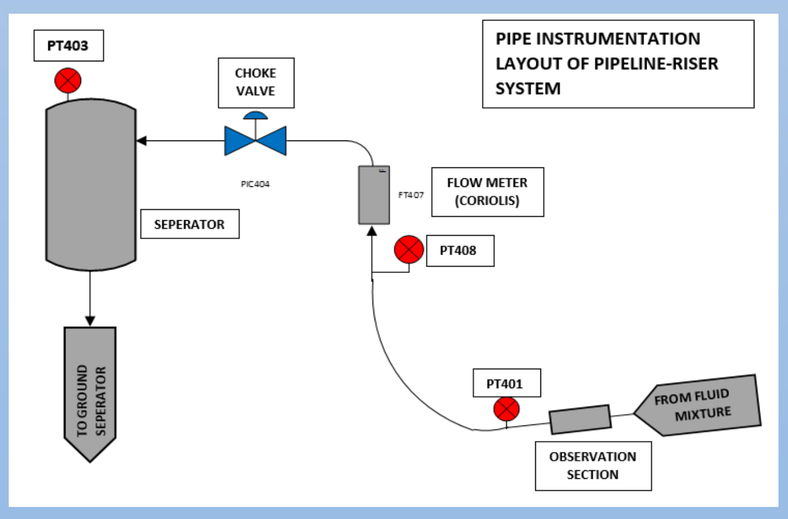
SIMULATION & EXPERIMENT FLOW PROPERTIES

Water		Air	
Mass Flow Rate	Superficial Velocity	Volumetric Flow Rate	Superficial Velocity
kg/s	m/s	Sm^3/h	m/s
1	0.109	20	0.217
2	0.218		
5	0.546		

*The experiment also used a choke valve to demonstrate what the effects of increased back pressure had on the system in terms of slug size and cycle period.

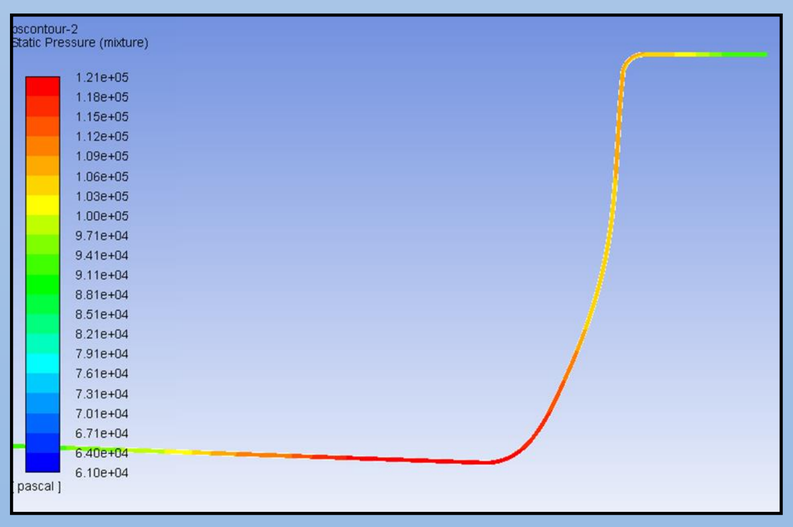
LAB EXPERIMENT

Experiments were carried out in the Process System Engineering (PSE) Lab at Cranfield University using a three-phase flow rig which can circulate air, water and oil at pressures up to 7 barg.



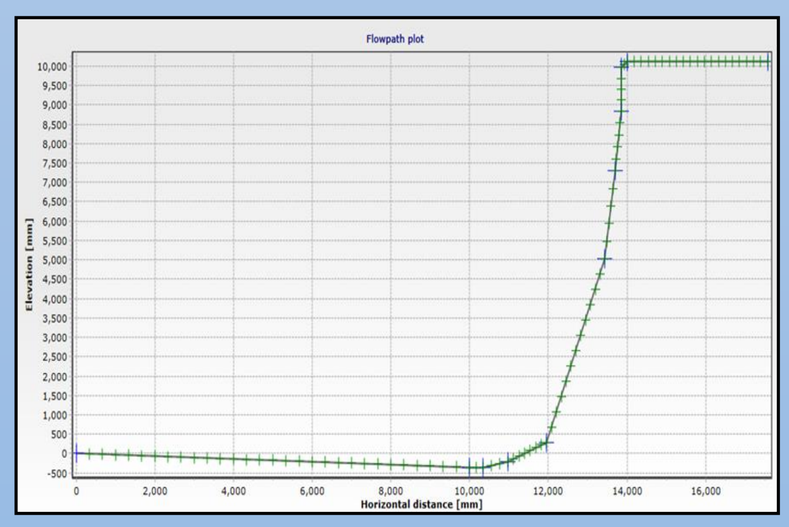
COMPUTATIONAL FLUID DYNAMICS (CFD) SIMULATION

CFD modelling provides a fundamental tool to support engineering design and research in multiphase systems Fluent is ran using High Performance Computing (HPC) at Cranfield.



OLGA SIMULATION

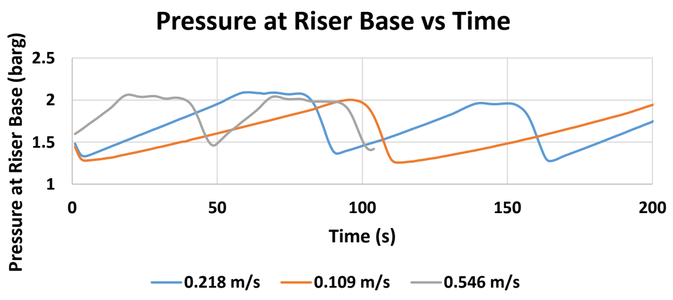
OLGA, a transient multiphase 1- dimensional simulation software which is developed and commercialised by Schlumberger is used to investigate severe slugging in the pipeline-riser system.

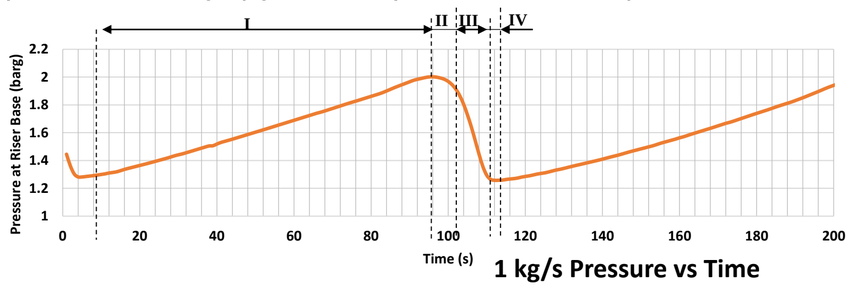


RESULTS

LAB RESULTS

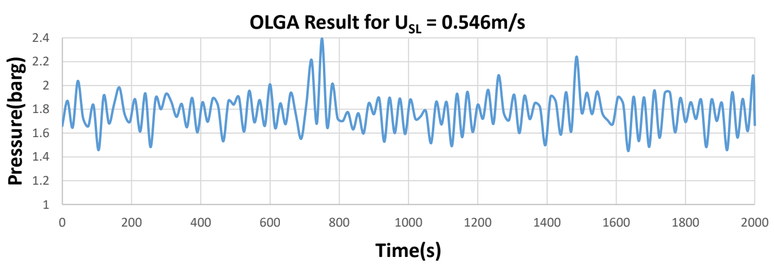
The variation of pressure with time in the pipeline-riser allows to better differentiate and classify severe slugging. One cycle of severe slugging can be classified into 4 stages: slug formation, slug production, blowout, and liquid fall-back (I, II, III, IV). Slugging increases with increasing superficial velocity, (cycle time-period decreases).

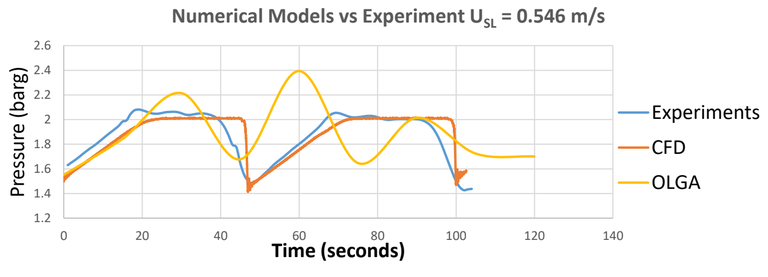




SIMULATION RESULTS

Both the CFD & OLGA simulations gave out very different results regarding the 3 different liquid superficial velocity settings. The overall trend of slugging is seen throughout all the simulations, there are cycles of high pressure build up, leading to a blowout (sudden drop in pressure). The CFD model creates a clear pressure-time graph of the slugging effect over time.





CONCLUSIONS

1. **The severe slugging phenomenon is caused by a combination of factors in a pipeline-riser system. The main factors include the pressure of the system, low fluid flow rates, inclination of the pipeline section. Increased fluid flowrate is directly proportional to increased slugging.**
2. **Numerical models have shown that they can simulate severe slugging in multiphase-flow to a useful degree of accuracy at a fraction of the cost of building a test rig system. They also have the added benefit of being able to create multiple models of any shape or size. However, CFD models require a relatively long computational time.**
3. **Severe slugging has a significant impact on a project's capital expenditure (CAPEX), operating expenditure (OPEX) and revenue.**

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