WATER HAMMER ANALYSIS IN PIPELINE NETWORKS

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INTRODUCTION

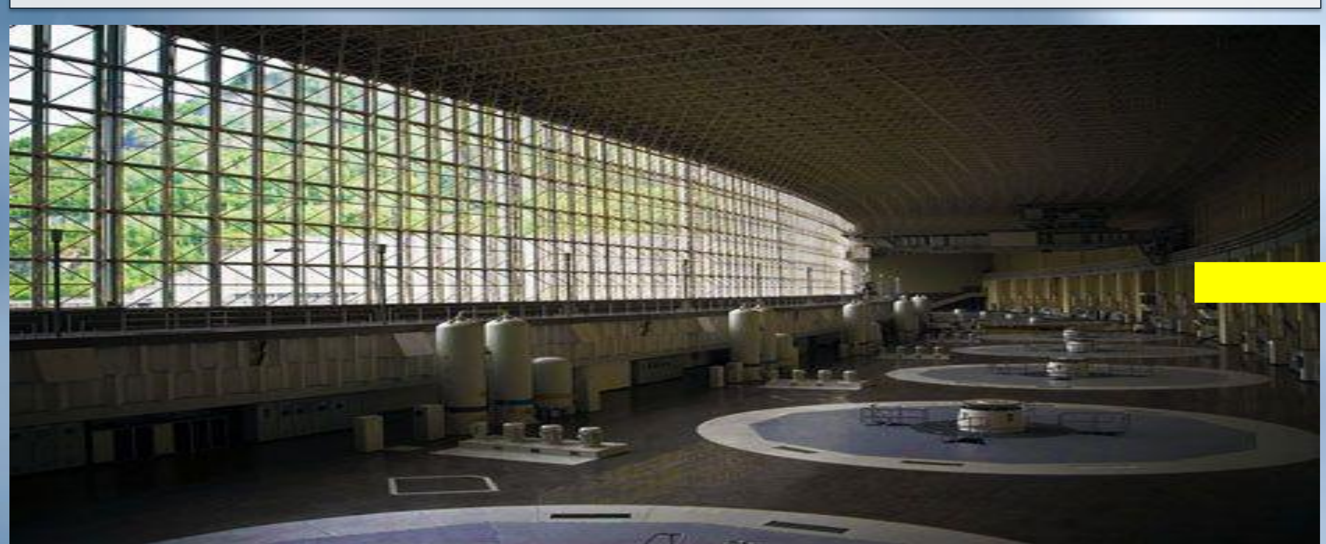
Water hammer is a commonly observed phenomenon within water distribution systems. It occurs when flow velocity is changed by an action such as a sudden valve closure/opening or pump/turbine malfunctions. The result of such events can include a range of consequences, from slight shudders within system elements to complete failure of structures (Ghidaoui et al. 2005).

RESEARCH GAPS

- General inability to accurately model water hammer events in networks of pipe.
- Currently cannot readily incorporate reduction of pressure changes over time (Covas, 2005).
- Unable to incorporate three dimension movements effects on transient waves (Tijsseling, 1999).

MOTIVATION

Knowledge of how 'water hammer' waves behave within pipe networks is not only key to solving issues resulting from such, but also has the potential to be used for pipe condition assessment applications such as leakage or blockage detection, hence improving the ways in which we manage water resources. By predicting pressure readings, procedures for pipe damage prevention can be created for companies.



OBJECTIVES/ APPROACH

AIM 1

Short-term Wave Behaviour

To investigate the impact of common physical elements of pipeline networks on water hammer waves and how these elements can be included in computer simulations.

Approach: Aim 1 will utilise the use of both experimental results gathered in the lab in conjunction with theoretical results developed in an external model. Model complexity will be iteratively increased until all physical components are captured.

AIM 2

Long-term Wave Behaviour

An exploration of the use of a non-conventional material model in describing the observed energy loss over time during a water hammer event in a pipeline network.

Approach: The Kelvin-Voigt viscoelastic model was used in an attempt to incorporate losses resulting from complex pipe movements which are difficult to predict.

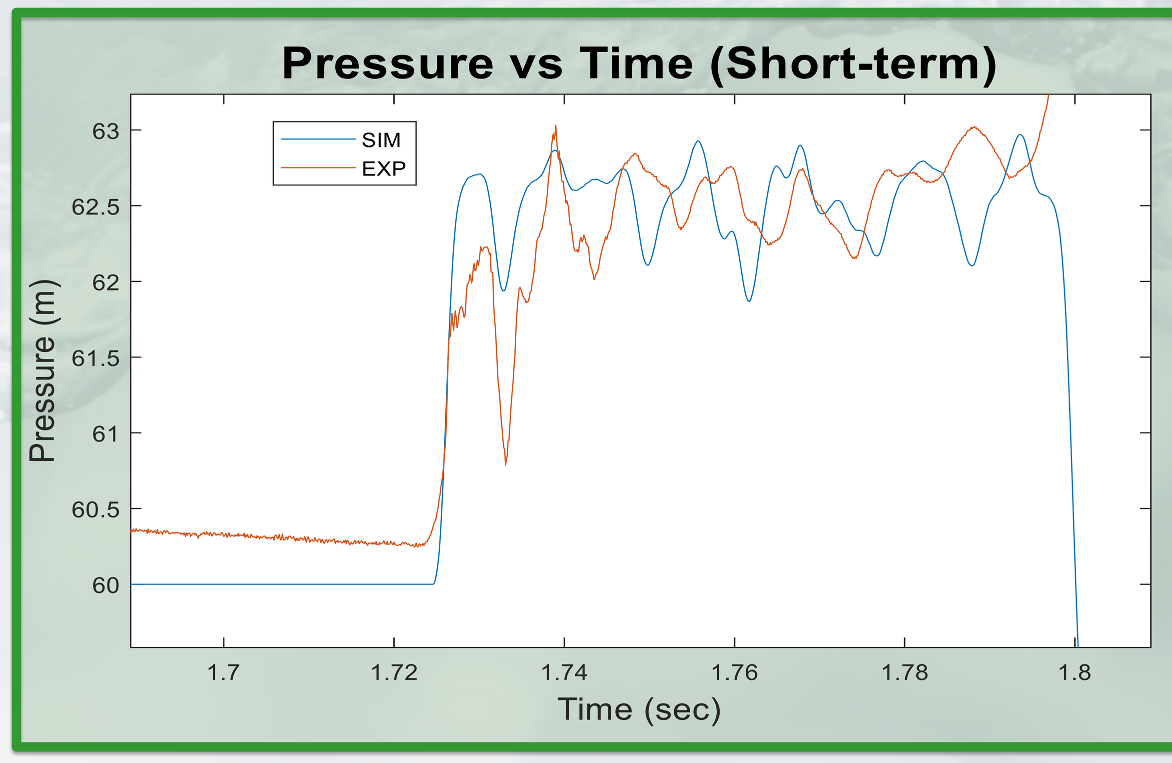
AIM 3

Pipe Movement Analysis

To form an observational study of structural layout's influence on the pipe network in three dimensions, while investigating the effects of such on transient waves.

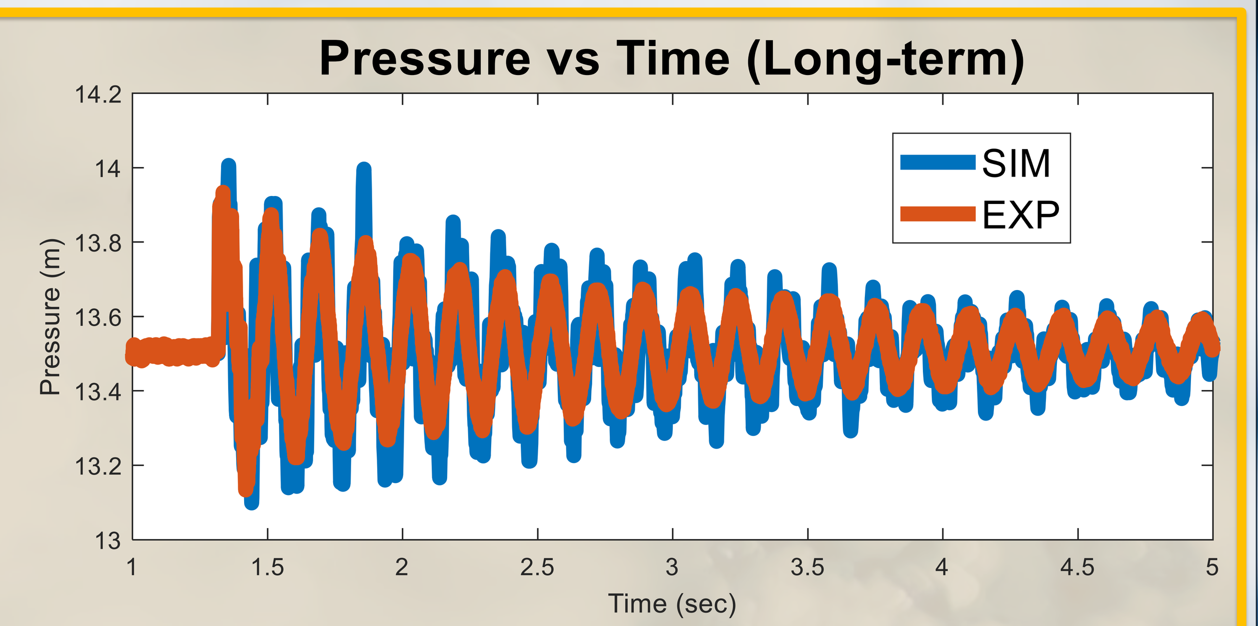
Approach: Accelerometers will measure the magnitude of pipe movements in three directions at junctions.

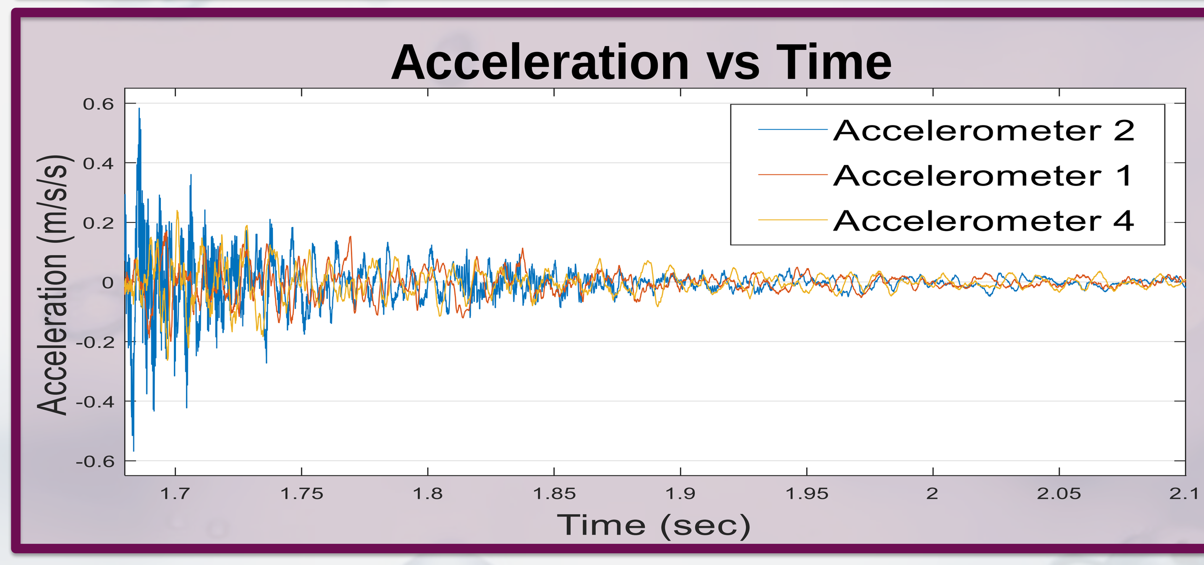
KEY FINDINGS



It was found that dead end walls pose the most noticeable impact on the transient waves' pressure over time. All major peaks and troughs can be contributed to the reflections caused from these dead end walls. Both blocks and flanges created smaller, less noticeable pressure movements, indicating that the varying wavespeed from the different pipe properties had little to no effect on modelling the transient wave over a much larger scale.

The Kelvin-Voigt viscoelastic model was extremely successful in incorporating equivalent losses resulting most likely from mechanical movements of pipe components in the network. In particular, the attenuation of low frequency waves could be accurately predicted while the model could not achieve similar success in predicting high frequency waves in the long-term.





Observational studies found that elbows and T-junctions experience the highest magnitude of movement during water hammer events. Pipes will experience twice the magnitude of pipe movement along the side walls compared to the top and bottom walls. Pipe movements will stop influencing transient waves after two periods of oscillation making structural damping a short term effect.

CONCLUSION

Transient waves caused by water hammer events can be destructive for pipelines. Discovering the components that effect these transient waves and accurately modelling the magnitude of potential pressure can support in the prevention of damage.

REFERENCES

Covas, D. et al., 2005. The Dynamic effect of pipe-wall viscoelasticity in hydraulic transient. Journal of Hydraulic Research, 43(1), pp. 56-70.

Ghidaoui, Mohamed & Zhao, Ming & McInnis, Duncan & Axworthy, David. (2005). A Review of Water Hammer Theory and Practice. Applied Mechanics Reviews - APPL MECH REV. 58. 10.1115/1.1828050.

Tijsseling, A.S., Heinsbroek, A.G.T.J.. (1999) The influence of bend motion on waterhammer pressures and pipe stresses, San Francisco USA.