Pressure Drop in Pipelines due to Pump Trip Event

Project Outline:

Background: SunWater is a bulk water infrastructure developer and manager owning around $7 billion in water infrastructure assets and supplying approximately 40% of all water used commercially in Queensland. As a specialist designer, builder, owner, and maintainer of pipeline water supply systems SunWater has a portfolio of more than 2,700km of pipeline in 15 systems which are high head systems supplying high reliability water to industrial and mining customers.

Motivation: At the early stages of the project life cycle of long distance large diameter high pressure water pipelines conceptual design is completed and the pipe, pump duty and route selection are optimised based on an assessment of capital expenditure and the net present value of on going power and maintenance costs. It's at this stage that engineers make assumptions on the quantities and locations of surge mitigation devices, which is used to develop high level cost estimates to establish the budget for the project.

Currently at early stages of design, positioning and the number of surge tank and/or aircushion type devices are primarily derived based on the pipeline's profile and in most cases by engineering experience and judgment. Surge devices are implemented on the pipeline system to alleviate pressures falling to sub atmospheric and/or causing full vaporisation of the water column. Full vacuum pressures have the potential for high pressure spikes setting up within the system when the water column recombines. The presence of these pressure spikes (or hydraulic shocks) leads to a phenomenon known as waterhammer. Some effects of waterhammer can be pipe burst or collapse, damage to linings and pipe joint systems, failure of valves and mechanical fittings.

Surge protection can be a significant proportion of the pipeline's capital costs and there is the potential during the early stage of the project to significantly under or over estimate the required level of surge mitigation and ensure its adequately costed for in the initial project budget. Detailed waterhammer analysis using commercial modelling programs can be costly and time consuming and are generally undertaken only at the latter stages of the project life cycle.

The Task: SunWater is interested in developing a more scientific approach of estimating the magnitude of the deceleration pressure drop at a pump station that would provide design engineers with an increased level of confidence in the surge protection allowed for at the early stages of design prior to any detailed waterhammer modelling, which is performed using commercial software.

This MISG project involves deriving a high-level "formula" for estimating the initial pressure drop at a pump station. The desired outcome would be a simple expression that calculates the proportion of the pump head that is lost during a pump trip in terms of the pump duty (Q & H) and/or pump characteristics (rpm, MOI), which is representative to the results obtained using commercial modelling software. As a starting point for this task delegates could focus on developing an expression for multiple centrifugal pumps in parallel for a simple pressurised system (pumping to a high-level tank or storage).