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CASE STUDY

Dynamic Simulation for High-Pressure Gas Pipeline Network

This case study is based on an AIChE technical paper titled 'Dynamic Simulation for High Pressure Gas Pipeline Network System'. The study focuses on a large-scale high-pressure natural gas pipeline network in Japan operated from the Sodegaura LNG terminal. The network spans approximately 300 km and includes multiple pressure control valve (PCV) stations. The objective was to evaluate controllability and operational stability when integrating a new pipeline segment (Kasai station ~ Souka station) equipped with a pressure control valve into an existing, complex pipeline system.

CHALLENGE

The existing high-pressure gas pipeline system experienced controllability issues during plant start-up, particularly due to interaction between pressure control valves at the Sodegaura and Kitano valve stations. With the planned addition of a new pipeline and pressure control valve at the Souka valve station, there was a high risk of increased interaction, pressure instability, and flow imbalance across the network. Manual tuning of PID parameters on-site was time-consuming and operationally risky, especially during start-up and emergency scenarios.

SOLUTION

A dynamic simulation model of the entire high-pressure gas pipeline network was developed using the CHEMCAD process simulator. The model was first validated against actual operational data from the existing pipeline system, including pressure, flow rate, and valve opening behavior. Using the validated model, the team evaluated interactions between existing PCVs and the new Souka PCV. Optimum PID control parameters were calculated using the Internal Model Control (IMC) method and applied to dynamic simulations under normal operation and emergency valve closure scenarios.

TOKYO GAS

- **Industries:** LNG / Natural Gas
- **Region:** Japan

RESULTS

The dynamic simulation closely matched actual plant data after initial transient conditions, confirming model accuracy. Simulation results showed that interaction between the new Souka PCV and existing PCVs was minimal when optimized PID parameters were applied. Pressure stability was maintained across the 300 km pipeline network during normal operation, and downstream pressure fluctuations were controlled effectively. In simulated emergency scenarios, such as closure of the Sodegaura PCV, the remaining control valves compensated automatically, maintaining overall system stability.

TANGIBLE BENEFITS

- Reduced start-up tuning time through pre-calculated PID parameters
- Improved pressure and flow stability across the entire pipeline network
- Minimized operational risk when integrating new pipeline infrastructure
- Enhanced preparedness for emergency shutdown scenarios
- Increased confidence in system controllability prior to commissioning

FIGURE 1 - High-pressure gas pipeline network layout showing LNG terminal, existing PCVs, and new Souka pipeline connection.

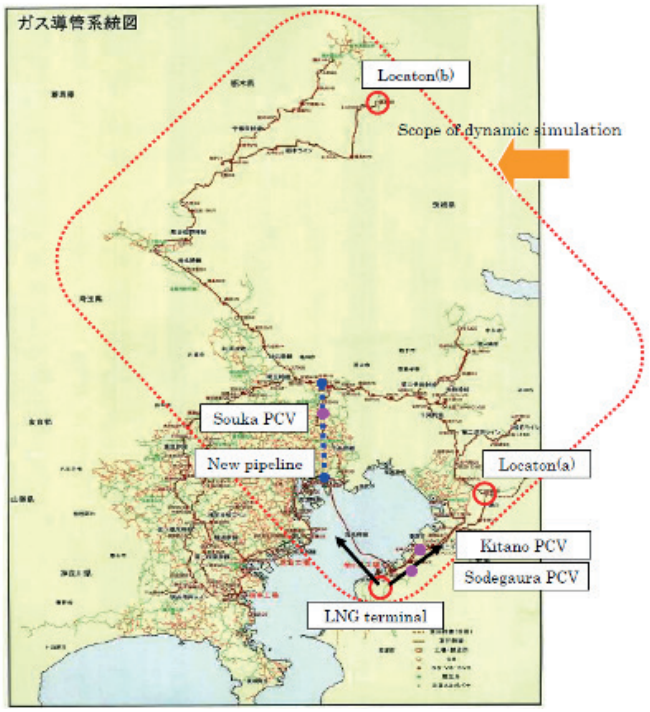

FIGURE 2 - Simulated vs. actual pressure trends at 60 km (location (a)) downstream from the LNG terminal