Cryogenic Natural Gas Distillation Process Simulation

Project Report

Prepared using Aspen HYSYS

Date: August 2025

Abstract

This project involves the dynamic simulation of a cryogenic natural gas distillation process using Aspen HYSYS. Key components such as cryogenic columns, LNG exchangers, a two-stage refrigeration system, and compressors were modeled. The study includes dynamic analysis, control strategy design, CO■ freeze-out assessment, and commissioning procedures.

Introduction

Cryogenic distillation is a critical step in LNG production, separating methane from heavier hydrocarbons at very low temperatures. Dynamic simulation helps evaluate system performance, control behavior, and safety during startup, shutdown, and disturbances.

Process Description

The process includes a cryogenic distillation column, LNG heat exchangers, two-stage refrigeration loops, and feed gas compressors. Natural gas is cooled and fractionated to remove heavier components before liquefaction.

Simulation Setup

Aspen HYSYS was used with the Peng-Robinson EOS. A dynamic model was built using real equipment parameters, operating conditions, and control loops. Boundary conditions were defined based on typical plant data.

Dynamic Model Components

Dynamic models of the distillation column, LNG exchangers, refrigeration systems, and compressors were developed. Each unit's dynamic response was assessed under varying loads and control actions.

Control Strategy Design

PID controllers were implemented for pressure, level, and flow control. An anti-surge control system was designed for the compressors. Open-loop tests provided tuning parameters and stability margins.

Dynamic Testing & Analysis

Step, ramp, and second-order input tests were applied to key variables. System responses were analyzed to determine process dynamics such as gain, time constant, and dead time.

CO■ Freeze-Out Analysis

The simulation identified potential zones for CO■ freeze-out, particularly at low temperatures in the cryogenic section. Operating strategies were recommended to avoid solidification risks.

Startup and Shutdown Procedures

Dynamic sequences for cooldown, pressurization, and equipment activation were simulated. Safe shutdown logic was also implemented to guide commissioning and decommissioning activities.

Results and Discussion

The simulation demonstrated stable operation under normal and disturbed conditions. Surge protection worked effectively, and control loops maintained product quality and safety margins.

Conclusion

The dynamic simulation of the cryogenic LNG process in Aspen HYSYS enabled detailed understanding of system behavior, helped identify control improvements, and supported safe operational planning.

References

1. Aspen HYSYS Documentation
2. LNG Process Engineering Textbooks
3. Research Papers on Cryogenic Separation
4. Compressor Surge Control Guidelines