APPLICATION OF DYNAMIC SIMULATION FOR LIQUEFIED NATURAL GAS (LNG) PLANT DEBOTTLENECKING

Ir. Siti Rafidah Moslim
Malaysia LNG Sdn. Bhd. (Subsidiary of PETRONAS)

1) PETRONAS LNG Complex

MLNG (1983)
MLNG DUA (1995)
MLNG TIGA (2003)

Total 25.7 Million Tonnes Per Annum (MTPA) of LNG Production Capacity

Bintulu, Sarawak, Malaysia

2) MLNG DUA Debottlenecking

Original Liquefaction Process (3 Modules):

- **Propane (C3) Pre-Cooled Mixed Component Refrigerant (MR) by Air Products and Chemicals Inc. (APCI)**

Opportunity for increased LNG Production capacity by 1.2 MTPA via:

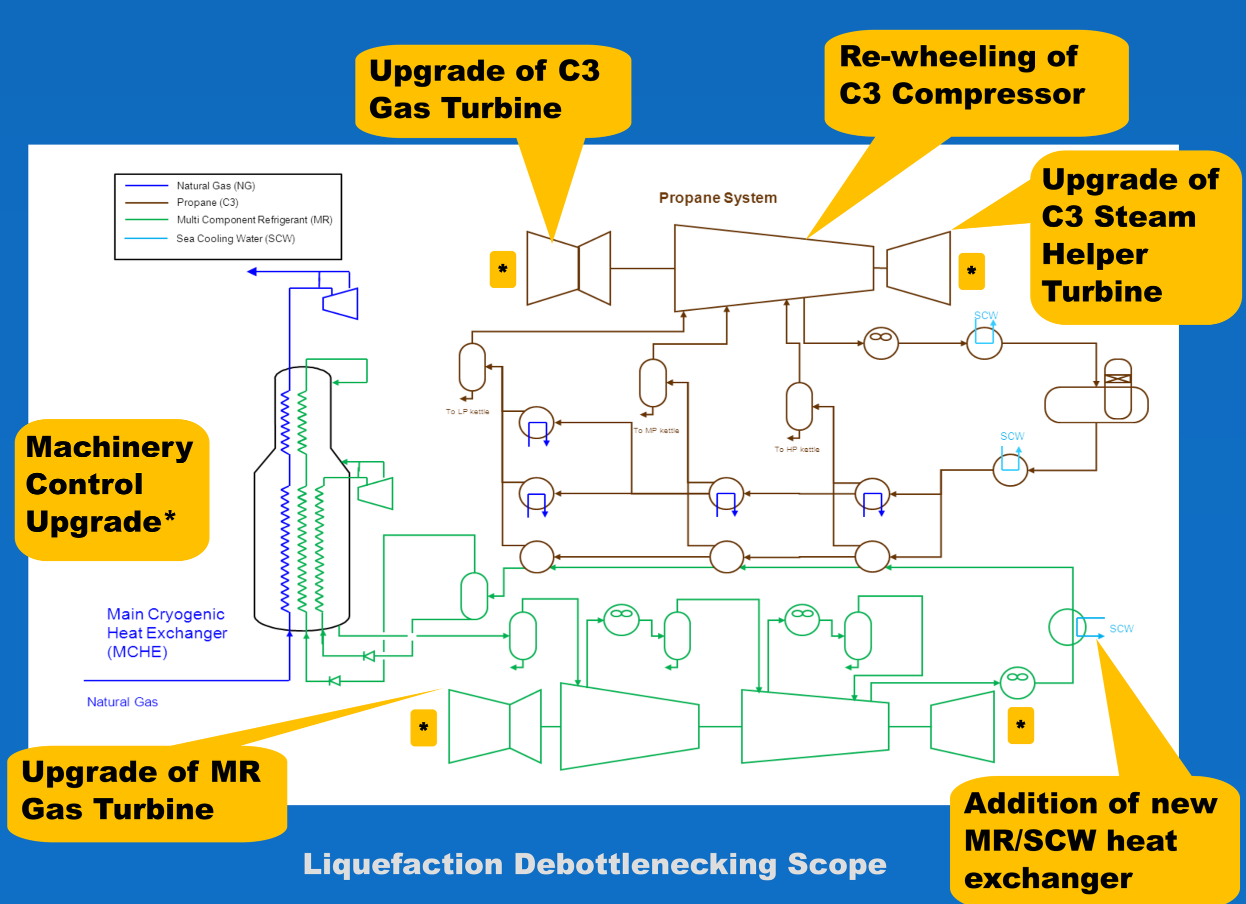
- **Alleviating existing constraints in the Liquefaction Unit (C3 and MR Refrigeration systems)**
- **Addition of Refrigeration capacity (New Extended End Flash Unit)**
- **Addition of Power Generation System (New Gas Turbine Generators)**
- **Tie-ins to existing utilities and common systems**

3) Application of Dynamic Simulation in Liquefaction Debottlenecking Scope

MR and C3 refrigeration circuits represent the heart of the LNG process. Assurance of process safeguarding is one of the prime concerns in the implementation of complex plant debottlenecking, particularly in the Liquefaction circuits.

Dynamic Simulation was carried out in two phases to address process safeguarding assurance:

- **Phase I** — **During Project development (with MR/SCW Heat Exchanger)**
- **Phase II** — **Operations phase (without MR/SCW Heat Exchanger)**

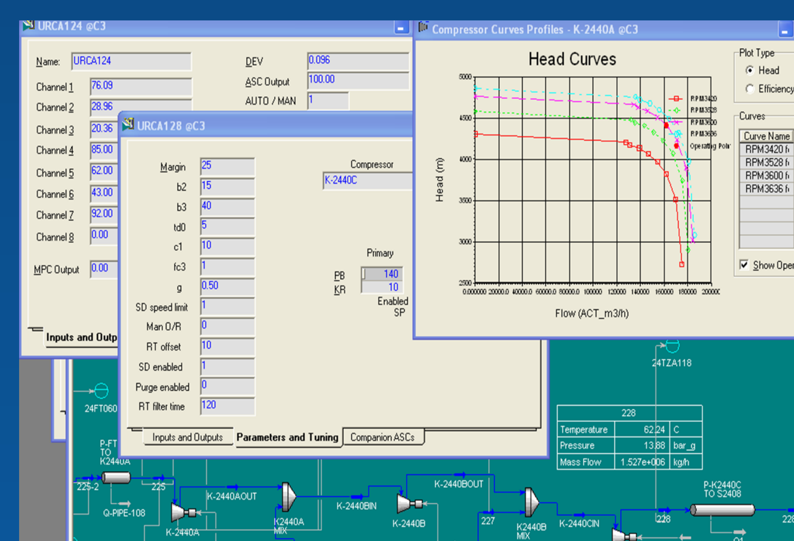


Liquefaction Debottlenecking Scope

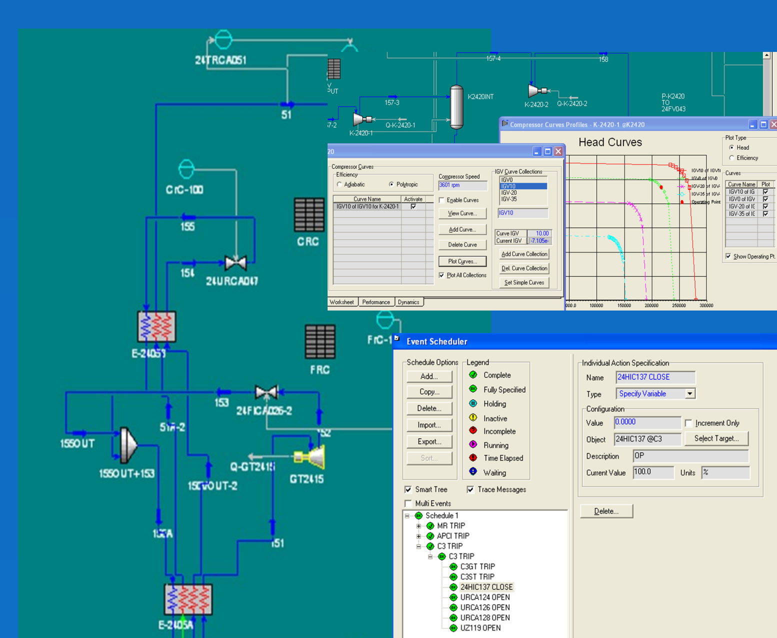
3.1) Study Objectives

- **To confirm the operability of the LNG plant debottlenecking design for a range of different operating cases, failure scenarios and variety of different start up conditions and procedures**
- **To verify and ensure controllability of the compressors during unit upsets, start-up, shutdown and normal operation scenarios to ensure the safe operation and protection of the compressors against the potential risk of damage due to surge under all scenarios**
- **To estimate the compressor system's settle out conditions and verify compressor systems' equipment design conditions**

3.2) Modeling Approach



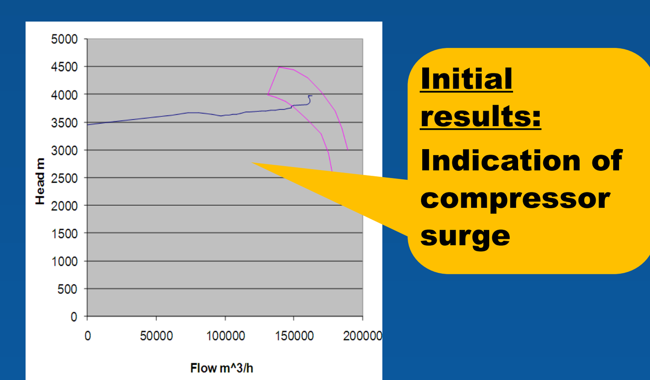
Main Component	Modeling Approach
Main Cryogenic Heat Exchanger (MCHE)	HYSYS LNG block tuned to design conditions
Axial and Centrifugal Compressors	Based on Vendor predicted curves (for initial dynamic scenarios) and as-tested curves (for finalization of dynamic scenarios)
Heat exchangers and chillers	Based on design heat transfer data
System volumes and resistance	Accurately modeled based on actual geometry and piping isometrics
Anti-Surge Control (CCC)	Emulated by using a customised block (not HYSYS anti-surge block)
Gas turbines and steam helper turbines	Using customised spreadsheets to reflect the process dynamics based on Vendor's machine inertia data

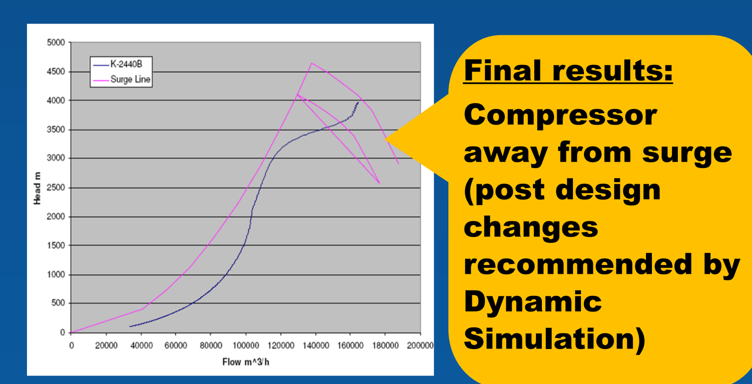


3.3) Study Work Flow

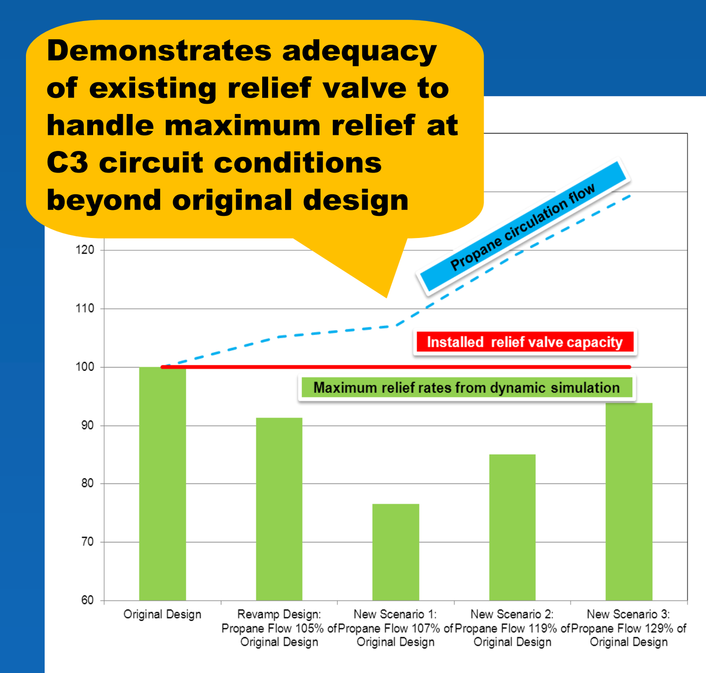
1. Kick-off meeting and input data gathering
2. Build stand alone dynamic models for NG, MR and C3
3. Dynamic models integration
4. Model testing to ensure robustness
5. Steady state validation with Heat and Material balance
6. Run Dynamic Scenarios (using HYSYS Event Scheduler)
7. Plot (>400) trends (MS Excel) for each scenario
8. Analyze results, draw conclusions and make recommendations
9. Repeat scenarios with the recommended changes (→ back to Run Dynamic Scenarios)
10. Recommended changes demonstrated to be workable for all dynamic scenarios
11. Prepare report summarizing results
12. Final meeting to address comments and questions

3.4) Benefits of Dynamic Simulation





- **Better sizing of recycle valves and bypass valves based on all failure scenarios compared to steady state**
- **Better insight gained into the integrated LNG process dynamics**
- **Anti-Surge controller (preliminary) tuning parameters developed and used as basis during commissioning**
- **Start-up and shutdown procedures tested in advance of actual plant start-up. Start-up procedure were modified to keep machine away from surge and stonewall region**
- **Improved sequencing of recycle valves opening during Main Cryogenic Heat Exchanger (MCHE) trip to keep machines away from surge**
- **Confirmed governing plant flare relief loads at various operating scenarios and emergencies**



3.5) Conclusion

- **Application of Dynamic Simulation is proven to be very effective in gaining very useful insights into the LNG process dynamics especially for complex plant debottlenecking.**
- **The study also helped to confirm further safe margin beyond existing design, particularly C3 circuit safeguarding, which is the governing case for existing flare design. This was pivotal in the optimized utilization of plant equipment in realizing increased LNG production capacity.**
- **Dynamic Simulation supports the realization of MLNG DUA debottlenecked capacity, which increased by 17.5% (1.2 MTPA).**