**Dynamic simulation of mixed refrigerant process for small-scale LNG plant (ID:465)**

Tianbiao He, Yonglin Ju*

Institute of Refrigeration and Cryogenics, Shanghai Jiao Tong University
E-mail: yjn@sjtu.edu.cn (Yonglin Ju)  hetianbiao@sjtu.edu.cn (Tianbiao He)

---

**Introducion**
Most of optimization studies concentrated on designing mixed refrigerant liquefaction process with lower energy consumption at steady-state simulation. Only a few studies have addressed dynamic simulation of natural gas liquefaction process. The main aim of this study was to conduct a dynamic simulation of mixed refrigerant liquefaction process for small-scale LNG plant and to investigate the dynamic responses of disturbances. The variations of natural gas composition, temperature, pressure, flow rate were adapted as disturbances to test the stability and dynamic responses of the process. The dynamic responses of LNG temperature and total energy consumption were the criteria to investigate the influences of disturbances on the process. Finally, the dynamic responses of disturbances were obtained and discussed.

---

**Process Design**

---

**Degrees of Freedom**

The number of manipulated variables of mixed refrigerant process in this study is 12 \( (N_{MV} = 12)\), the details are shown as follow:

1. One natural gas feed valve (VLV-1)
2. Two throttling valves in mixed refrigerant process (VLV-2, VLV-3)
3. Two heat duties of water coolers (Q-1, Q-2)
4. One compressor speed
5. Two anti-surge valves (VLV-7, VLV-8)
6. Three liquid holdup valves (VLV-4, VLV-5, VLV-6)

The number of degrees of freedom with no steady-state effect is 3 \( (N_{SS} = 3)\).

---

**Results and analysis**

1. **Validation of dynamic results**
   - Dynamic simulation results are verified by comparing with steady-state simulation results.
   - Most of the variables in dynamic simulation is within \( 0-5\% \) deviation of steady-state simulation.

2. **Disturbance of feed gas temperature**
   - The feed gas temperature is varied by 1, 2 and 3\( ^\circ \)C downward and upward.
   - LNG temperature and NG-3 temperature can go back to set point values with 300 mins. The bigger disturbance, the more oscillation.
   - Compressor duty will decrease when feed gas temperature decrease and increase when feed gas temperature increase.

3. **Disturbance of feed gas pressure**
   - The feed gas pressure is varied by 100, 200 and 300 kPa downward and upward.
   - The decrease of feed gas pressure has a bigger influence on the process than the increase of feed gas pressure.
   - Compressor duty will decrease when feed gas pressure decrease, while has little change when feed gas pressure increase.

4. **Disturbance of feed gas composition**
   - The methane composition is varied by 1%, 2% and 3% downward and upward.
   - The variation of methane composition can make the process a big oscillation.
   - The process needs to spend 400 mins to go back to stable state.

5. **Disturbance of feed gas flow rate**
   - The feed gas flow rate is varied by 1, 1.5 and 2 kmole/h downward and upward.
   - The decrease of feed gas flow rate has a smaller influence on the process.
   - Compressor duty will decrease when feed gas temperature decrease and increase when feed gas temperature increase.

---

**Conclusion**

1. Dynamic simulation of mixed refrigerant liquefaction process for small-scale LNG plant was developed to investigate the dynamic behaviors.
2. The comparison showed good match between dynamic simulation and steady-state simulation.
3. The results indicated that the process can handle these kinds of disturbance and go back to the specified values after some times.
4. The mixed refrigerant process showed good operation flexibility and can estimate different kinds of disturbance in a wide range.