C13 Isotope Recovery From Natural Gas Using Batch Distillation Column

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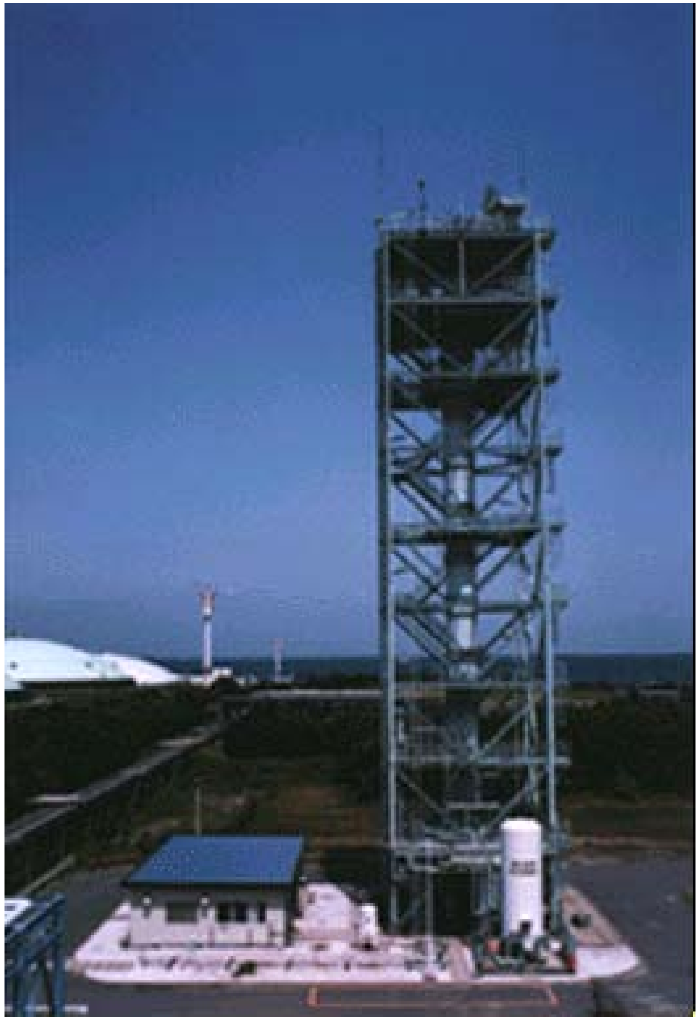
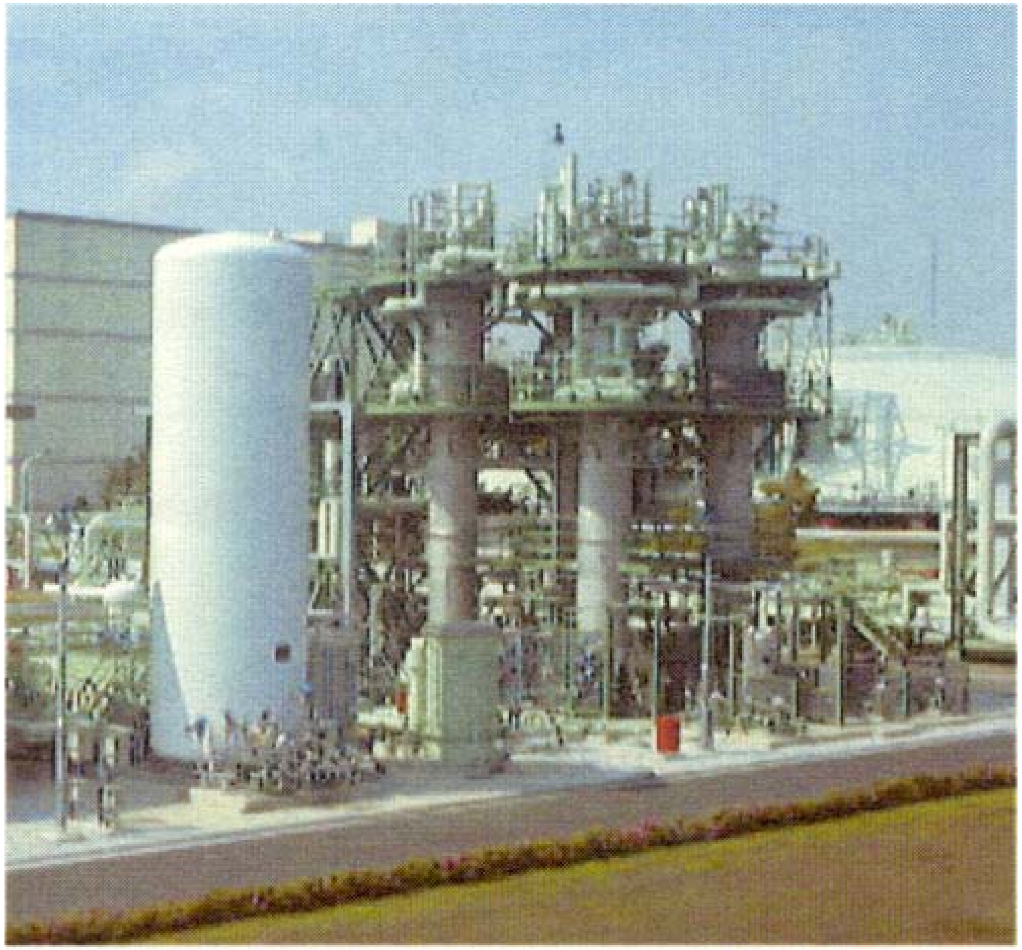
국외 연구 동향: 일본 Tokyo Gas





'99. 4., 90kg/yr, 건설비 : 25억엔

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Relative Volatility for $^{12}CO/^{13}CO$ System

- In case of distillation of carbon monoxide, ^{12}CO has about 0.5% higher vapor pressure than ^{13}CO, or the relative volatility for the $^{12}CO/^{13}CO$ system is 1.005.

From “Isotope Separation by Distillation”

Alpha for $^{12}CO/^{13}CO$ as a Function of Composition

$X(^{12}CO)$	$Y(^{12}CO)$	Alpha
0.1	0.100443	1.004925
0.2	0.200787	1.004924
0.3	0.301033	1.004926
0.4	0.401180	1.004926
0.5	0.501229	1.004928
0.6	0.601179	1.004927
0.7	0.701032	1.004931
0.8	0.800786	1.004932
0.9	0.900442	1.004933

Relative Volatilities btn C12 & C13

- Definition of relative volatility of component ‘i’ and component ‘j’ is:

$$\alpha_{ij} = \frac{K_i}{K_j} = \frac{(P_i / P)}{(P_j / P)} = \frac{P_i}{P_j}$$

(component ‘’ is defined as more volatile than component ‘j’)

Shortcut: Fenske Equation for Minimum Number of Stages

- Minimum number of stages can be determined using Fenske equation

$$N_{min} = \frac{\ln\left[\dfrac{x_D/(1-x_D)}{(1-x_B)/x_B}\right]}{\ln\alpha} = \frac{\ln SF}{\ln\alpha}$$

- SF (separation factor) is defined as:

$$SF = \left(\frac{x_{D,LK}}{x_{D,HK}}\right)\left(\frac{x_{B,HK}}{x_{B,LK}}\right)$$

Feedstock Characterization

Components	Mole Percent
12CO	50.0
13CO	50.0
Flow-rate (Kg-mole/hr)	100.0

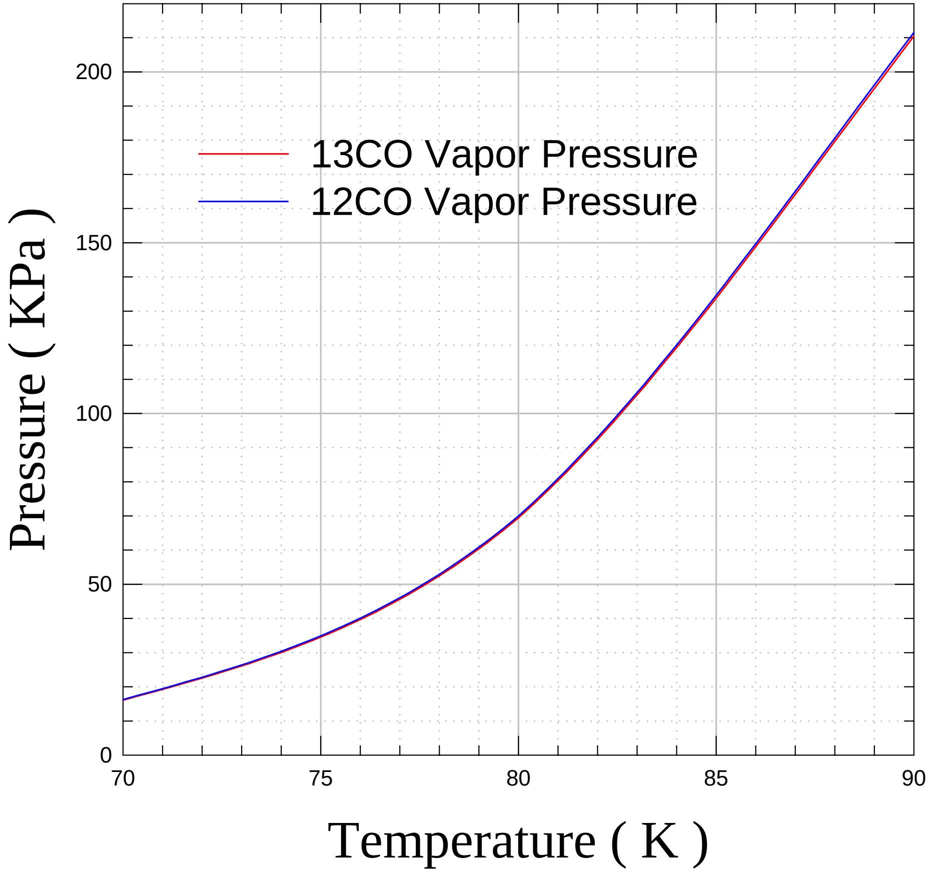
C13 Property Calculation Using SRK

- We used Soave Modified Redlich-Kwong equation of state for the modeling of methane isotope separation.

$$P = \frac{RT}{V-b} - \frac{a \cdot \alpha}{V\left(V+b\right)}$$

- Parameter ‘a’ and ‘b’ are functions of critical temperature and pressure.
- Alpha value is functions of reduced temperature and acentric factor.
- Acentric factor of 13CO was adjusted to accurately estimate vapor pressure at a given temperature.

Comparison of ^{13}CO Vapor Pressure btn Correlation & Modified SRK Equation



- Acentric factor of ^{13}CO, ω was modified as 0.095 to fit the vapor pressure vs. temperature.

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Comparison of ^{13}CO Vapor Pressure btn Correlation & Modified SRK Equation

Temperature	Vapor Pressure of ^{13}CO	Vapor Pressure of ^{12}CO
70.0 K	16.07 kPa	16.25 kPa
80.0 K	69.44 kPa	69.98 kPa
90.0 K	210.46 kPa	211.56 kPa

- ^{12}CO has about 0.5% higher vapor pressure than ^{13}CO at 90.0 K.

$$\left|\frac{211.56-210.46}{211.56}\right|\times 100 = 0.52\%$$

The End….