제 1차 정보제공: 천연가스 처리공정의 개요

2016년 4월 20일(수)

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<u>조 정 호</u>

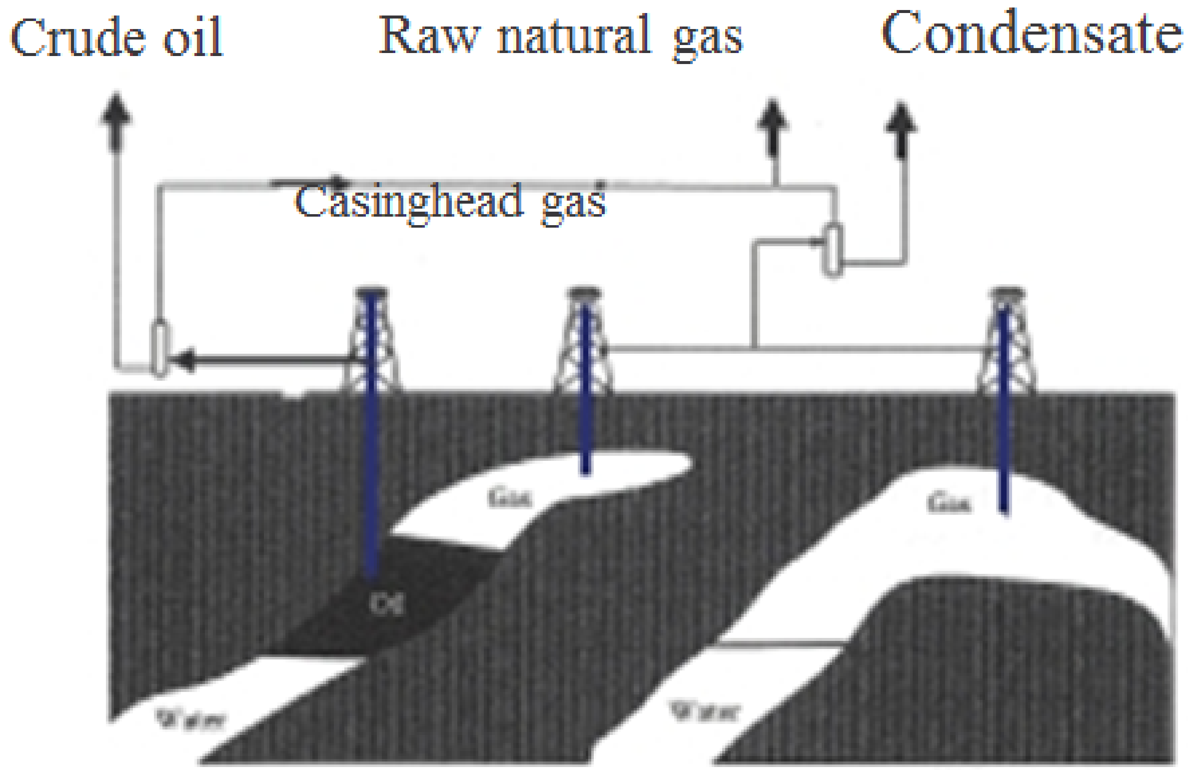
Agenda

1 Overview of Natural Gas Industry

Types of Natural Gas Wells

- Crude Oil Well: Associate Gas
- Gas Well
- Condensate Well
- Coalbed

(Gas Well, Condensate Well) } Non-associated gas



Natural Gas Composition

- Although the gases shown above are typical, some gases have extreme amounts of undesirable components. For example, according to Hobson and Tiratso (1985), wells that contain as much as 92% carbon dioxide (Colorado), 88% hydrogen sulfide (Alberta, Canada) and 86% nitrogen (Texas) have been observed.

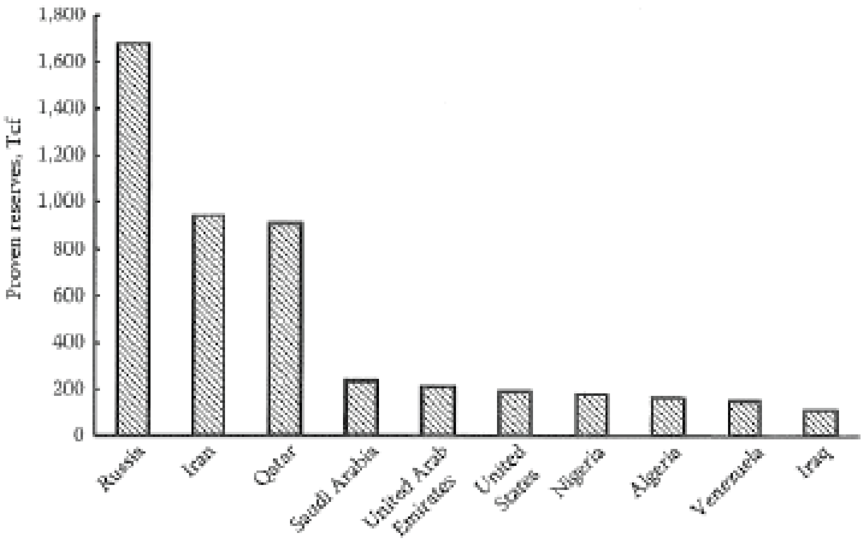
	Cleaveland	Lac1 Profo	Groningen	West Sole	Alberta	HassiR'Mel	Afan	Murban	Chivo
	USA	France	Netherland	UK	Canada	Algeria	Nigeria	Abdabi	Russia
CH4	93.3	69	81.3	94	91.9	83.7	81	76.4	92.8
C2H6	3.5	3	2.9	3.3	2	6.8	6.5	8.1	3.9
C3H8	0.7	0.9	0.4	0.6	0.9	2.1	5.9	4.7	1.7
C4H10	0.2	0.5	0.1	0.2	0.3	0.8	3.3	2.7	0.8
C5+	0	0.5	0.1	0.2		0.4	1.4	1.8	0.3
CO2	1.8	9.3	0.9	0.5		0.2	1.7	4.4	0.3
N2	1.5	14.3	1.2	0.4	4.9	5.8	0.2	0.2	
O2								0.3	0.2
others						0.2(He)		1.7	

Impurities

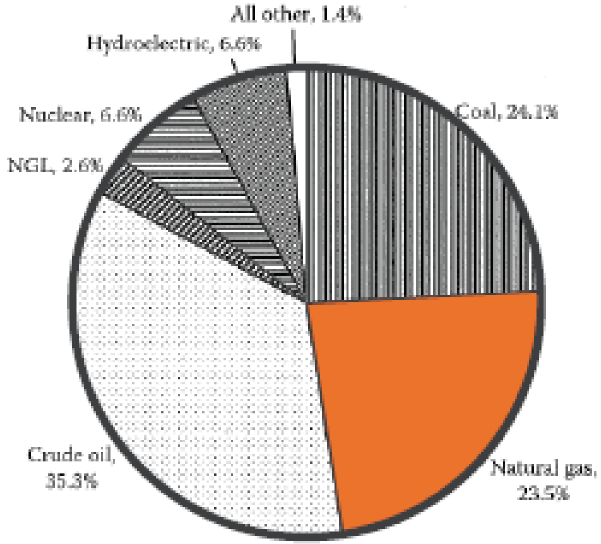
- Water: trace-saturation
- Sulfur species: If the hydrogen sulfide (H2S) concentration is greater than 2 %, carbonyl sulfide (COS), carbon disulfide (CS2), elemental sulfur and mercaptans (R-SH) may be present.
- Mercury. 0.01 to 180 ~glNm3. Need to remove to 0.01 ~glNm3 to protect aluminum heat exchangers.
- NORM: Naturally occurring radioactive materials
- (NORM) may also present problems in gas processing.

Natural Gas as Energy Resources

➤ Current Situation



Major proven natural gas reserves by country



Primary resources of energy in the world in 2003.

Natural Gas Processing Plant

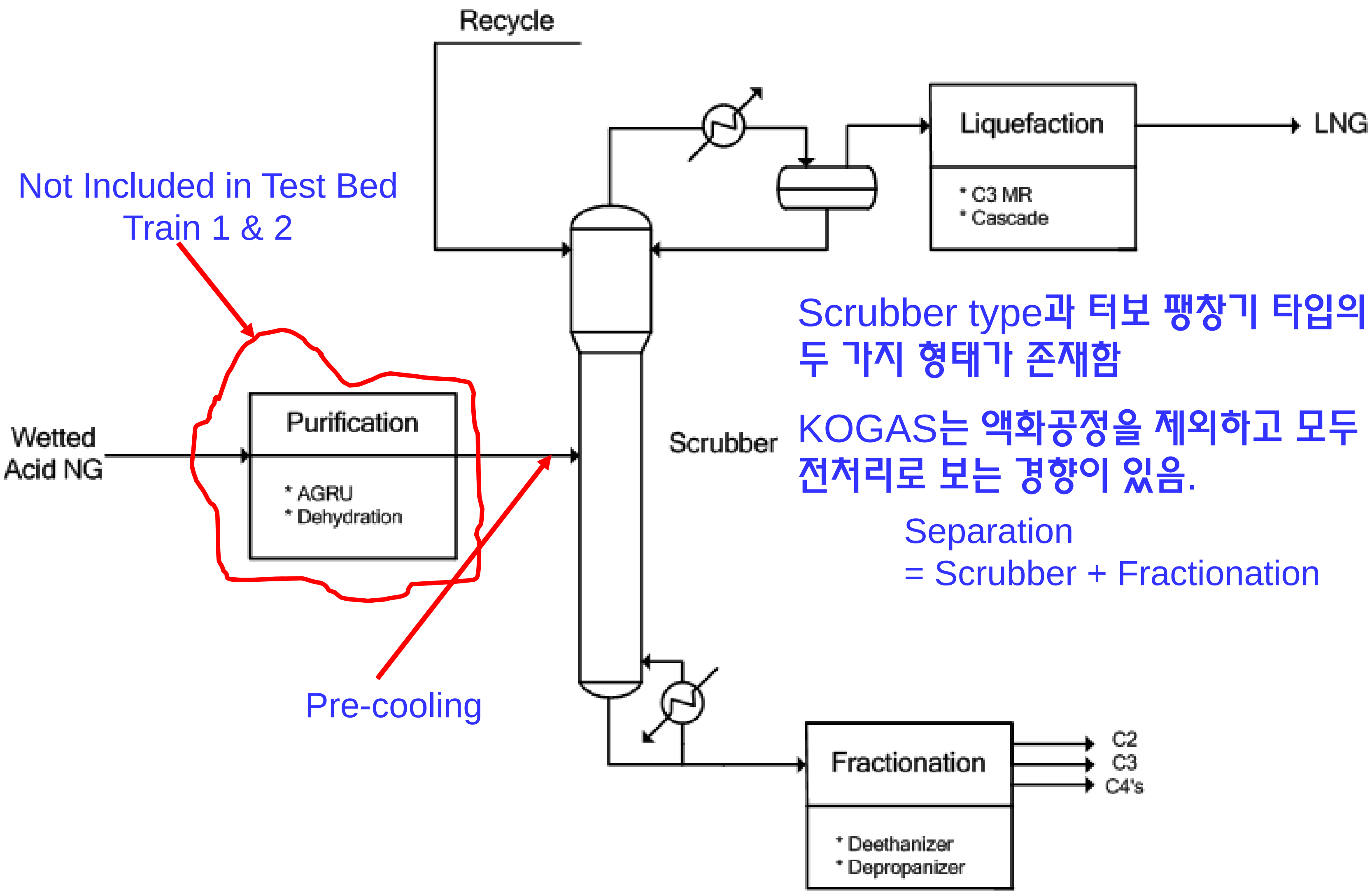
- Brief Explanation of Natural Gas Processing Plant Using Only 3 Keywords.

  - Purification: Pretreatment before Liquefaction of Natural Gas
    - ✓ Impurities Removal Processes
  - Separation: NGL Recovery such as C2, C3 or C4 from Natural Gas
    - ✓ Recovery of Valuable Components
  - Volume reduction: Liquefaction of Natural Gas
    - ✓ Refrigeration Process

Natural Gas Processing Plant & LNG

- There are basically three objectives in natural gas processing: 1)purification, 2)separation and 3)volume reduction.
  - **Purification** is the removal and discarding of undesirable components from natural gas.
    - ✓ Impurities: CO_2, H_2S, Hg, H_2O(Gas dehydration rather than gas treating), etc
    - ✓ AGRU, Dehydration, Mercury Removal, etc
  - **Separation** is the recovery for future sale of one or more of the desirable components in the natural gas.
    - ✓ Ethane, Propane, Butane, etc
    - ✓ Turbo-expander unit or (Scrubber column), Deethanizer, Depropanizer, etc
  - **Volume reduction** is the liquefaction of natural gas to facilitate storage or transportation
    - ✓ Refrigeration Cycle
    - ✓ Cascade refrigeration, C3 MR, etc

Natural Gas Processing Plant & LNG



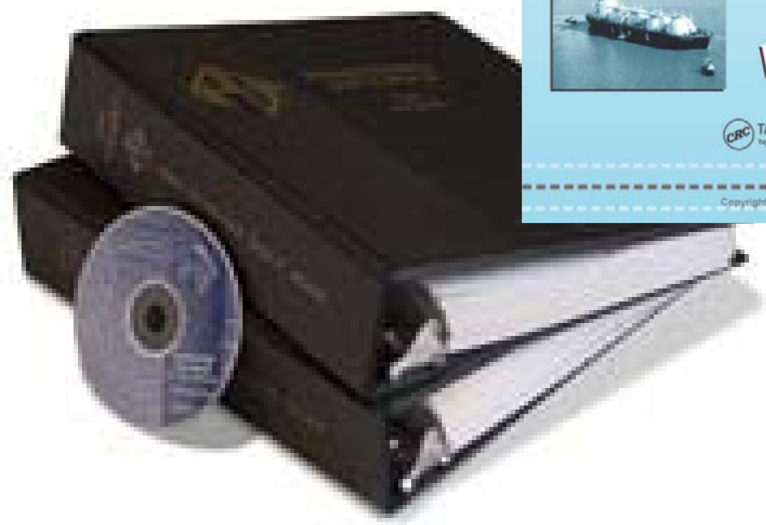
Scrubber type과 터보 팽창기 타입의 두 가지 형태가 존재함

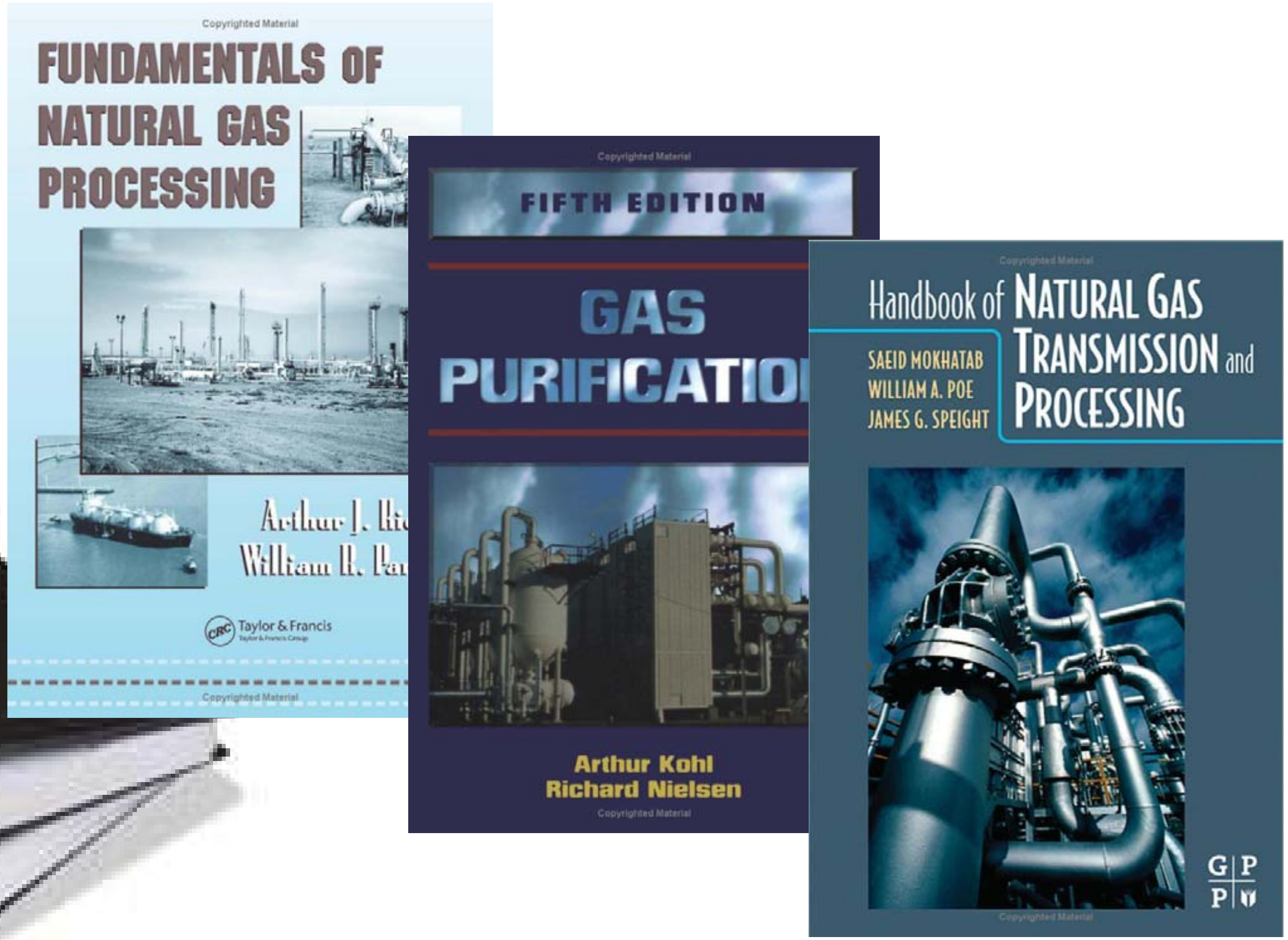
KOGAS는 액화공정을 제외하고 모두 전처리로 보는 경향이 있음.

Separation
= Scrubber + Fractionation

Recommended Books for Natural Gas Processing

4권 모두 pdf 파일로
가지고 있음





Recommended Books for Natural Gas Processing

- CO_2
  - ✓ 50 ~ 100 ppmv: (< 50 ppmv)
  - ✓ Freeze out on cold surfaces
- Water
  - ✓ < 0.1 ~ 0.5 ppmv (< 1 ppmv: 수정할 필요 있음.)
  - ✓ Freeze out on cold surfaces
- H_2S
  - ✓ 4 ppmv (< 4 ppmv)
  - ✓ Product specification

2 천연가스 내 산성가스 제거공정

CO_2 Removal (Acid Gas Removal) Processes

- Solvent based absorption
  - Physical absorption process
    - Based on gas solubility in solvent (Rectisol, Selexol, Purisol)
    - Advantageous at high partial pressures of CO_2: $y_{CO_2}P = H_{CO_2}x_{CO_2}$
    - Disadvantage: Co-solution of hydrocarbons in solvent
  - Chemical absorption process
    - Based on exothermic chemical reaction (solvent heats up)
      - ✓ Alkanolamines most common: MEA, DEA, MDEA, DIPA
      - ✓ Mixed amines (MDEA+Piperazine): Activated or accelerated MDEA
    - Regenerated by endothermic stripping process (heat supplied)
      - ✓ Disadvantages: Regeneration energy (varies with chemicals)
  - Hybrid solutions
    - Mixed physical and chemical: (Sulfinol-D & Sulfinol-M)

CO_2 Removal (Acid Gas Removal) Processes

- Cryogenic removal
  - Cooling and distillation: (Ryan-Holmes Process)
- Adsorption
  - Small concentration and flow rate
- Membrane process
  - Bulk removal
  - No low concentration

Solvent Based Acid Gas Removal Processes

Absorption Process	Solvent	Process conditions	Developer/Licensor
Physical Solvent			
Rectisol: DME DEMO Plant	Methanol	-10~-70°C, >2 MPa	Lurgi and Linde (Germany), Lotepro Corporation (USA)
Purisol	n-methyl-2-pyrolidone (NMP)	-10~+40°C, >2 MPa	Lurgi (Germany)
Selexol: DME FPSO에 적용	dimethyl ethers of polyethylene glycol (DMPEG)	-40°C, 2~3 MPa	UOP (USA)
Fluor Solvent	Propylene Carbonate	Below ambient temperatures, 3.1 ~6.9 MPa	Fluor, El Paso (USA)
Chemical Solvent			
Organic (Amine Based)			
MEA	2.5 n monoethanolamine and chemical inhibitors	~40°C, ambient to intermediate pressure	Dow Chemical (USA)
Amine Guard (MEA)	5 n monoethanolamine and chemcal inhibitors	~40°C, ambient to intermediate pressure	Union Carbide (USA)
Econamine (DGA)	6 n diglycolamine	80~120°C, 6.3 MPa	SNEA (Fracnce)
ADIP (DIPA & MDEA)	2~4 n diisopropanolamine/ 2 n methyldiethanol amine	35~+40°C, >0.1 MPa	Shell (Netherland)
MDEA	2 n methyldiethanol amine	Below ambient temperatures, 3.1 ~6.9 MPa	
Flexsorb/KS-1, KS-2, KS-3	Hindered amine		Exxon (USA), M.H.I (Japan)
aMDEA	Composition Not Known		**BASF (Germany)**
Inorganic			
Benfield Process	K2CO3	70~120°C, 2.2~7 MPa	Lurgi (Germany)
Physical/Chemical Solvents			
Sulfinol-D and Sulfinol-M	Mixture of DIPA or MDEA, water and tetrahydrothiopene or DEA	>0.5 MPa	Shell (Netherland)
Amisol	Mixture of methanol and MEA, DEA, DIPA or MDEA	5~40°C, >0.5 MPa	Shell (Netherland)

Amines

- Amines are compounds formed from ammonia(NH_3) by replacing one or more of the hydrogen atoms with another hydrocarbon group.
- Replacement of a single hydrogen produces a primary amine, replacement of the two hydrogen atoms produces a secondary amine, and replacement of all three of the hydrogen atoms produces a tertiary amines.
- Primary amines are the most reactive, followed by the secondary and tertiary amines.
- The amines are used in water solutions in concentrations ranging from approximately 10 to 65 wt% amines.
- All commonly used amines are alkanolamines, which are amines with -OH groups attached to the hydrocarbon groups to reduce their volatility.

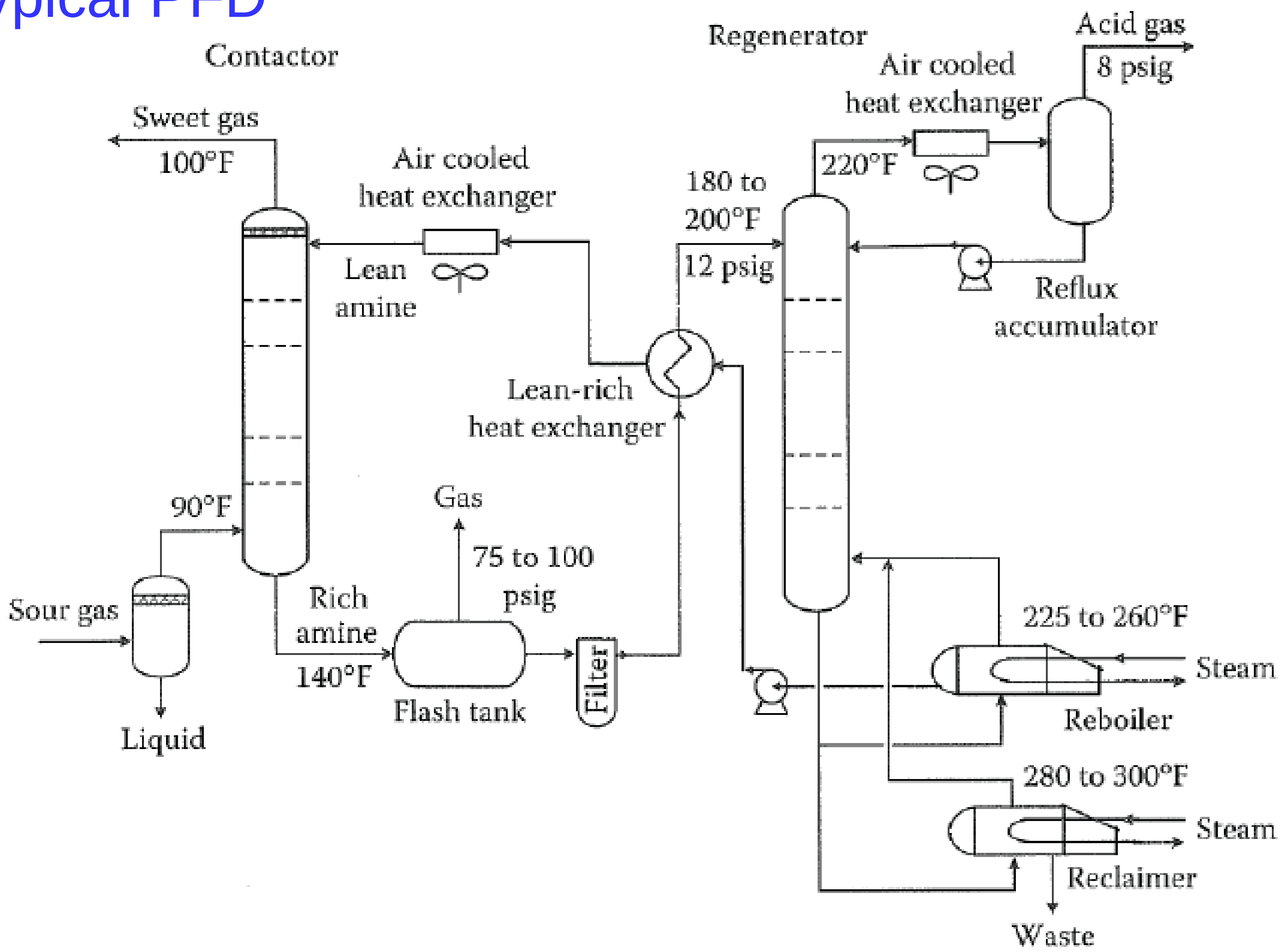
Amines

- Amines remove H_2S and CO_2 in a two step process:
  - The gas dissolves in the liquid phase (physical absorption).
  - The dissolved gas, which is a weak acid, reacts with the weakly basic amines.

- Absorption from the gas phase is governed by the partial pressure of the H_2S and CO_2 in the gas, whereas the reactions in the liquid phase are controlled by the reactivity of the dissolved species.

Aqueous Alkanolamine Processes

- Typical PFD

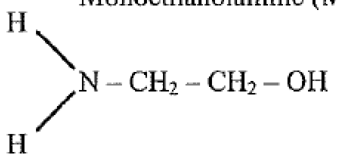


Aqueous Alkanolamine Processes

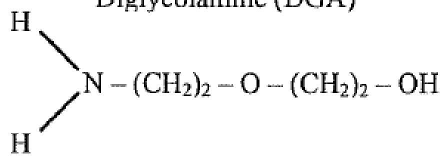
➢ Structure of the commonly used amines

Primary Amines

Monoethanolamine (MEA)

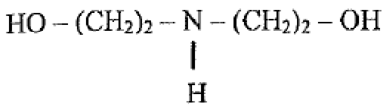


Diglycolamine (DGA)

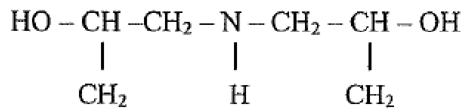


Secondary Amines

Diethanolamine (DEA)

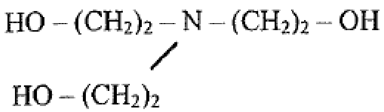


Diisopropanolamine (DIPA)

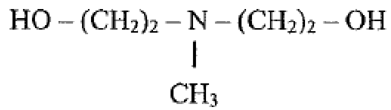


Tertiary Amines

Triethanolamine (TEA)

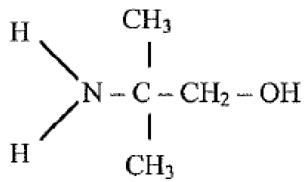


Methyldiethyanolamine (MDEA)



Sterically Hindered Amine

2-amino-2methyl-1-propanol (AMP)



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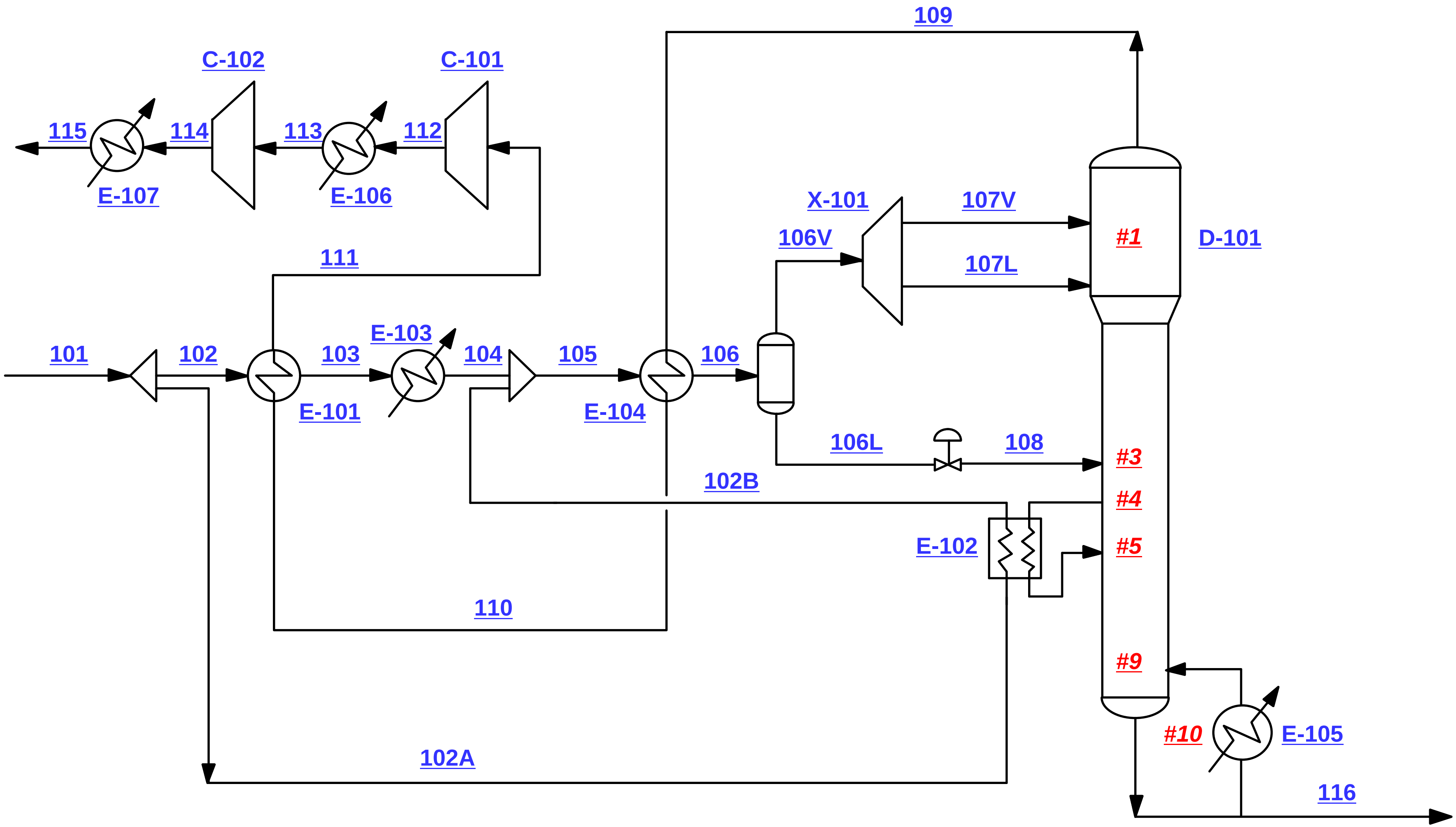
NGL (Natural Gas Liquids) 회수공정 최적화

Schematic Diagram for NGL Recovery Column



Process Description

- Gas is dehydrated usually by molecular sieve.
- Gas is partially chilled by back-exchange with residue gas.
- Gas is further chilled by refrigeration system
- Gas is further chilled demethanizer overhead gas.
- Extremely low temperature stream is obtained by letting-down the pressure using turbo-expander.
- Ethane & heaviers are obtained by further fractionations.

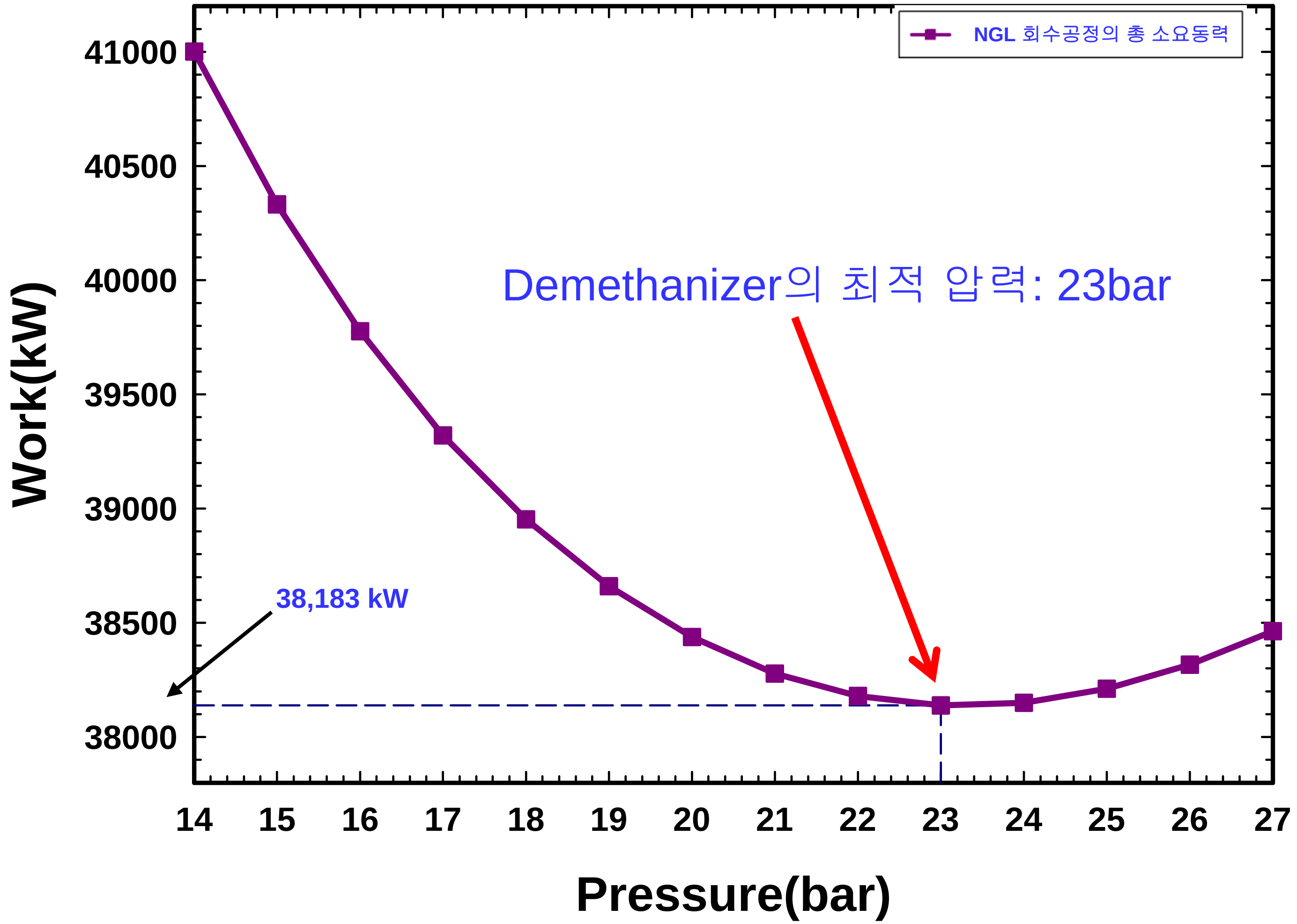
Feedstock Information

Contents	Value
Pressure (bar)	70
Temperature (°C)	45
Flow Rate (kg/hr)	625,000

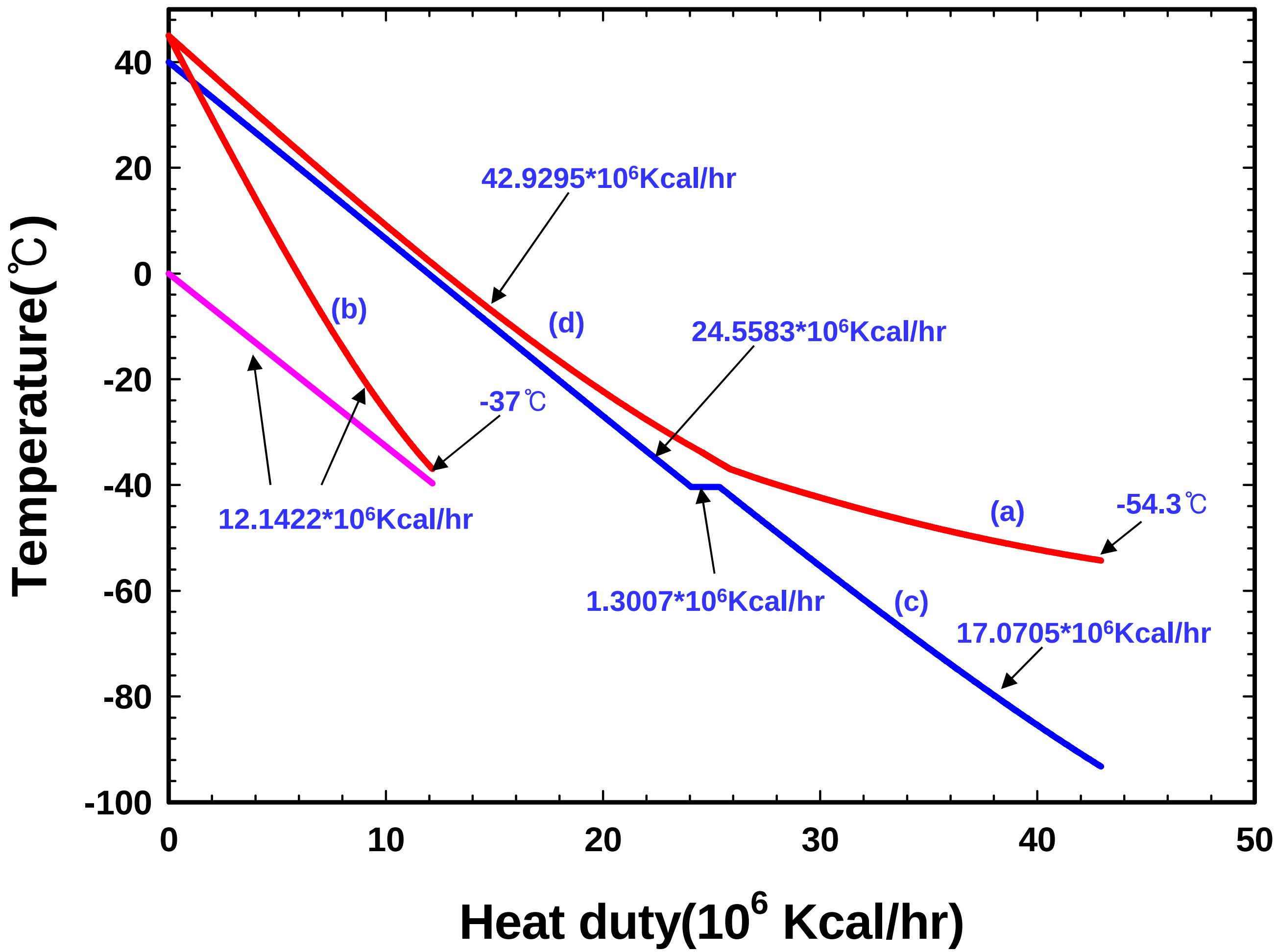
Component	Mole%
Nitrogen	0.22
Methane	91.33
Ethane	5.36
Propane	2.14
I-Butane	0.46
N-Butane	0.47
I-Pentane	0.01
N-Pentane	0.01
Total	**100**

Demethanizer Top Pressure 변화에 따른 소요 동력의 변화

탈메탄탑의 압력이 **23 bar**일 때
NGL 회수공정에 필요한 총 소요동력이 최소



Heating and Cooling Curces



전산모사 결과 요약

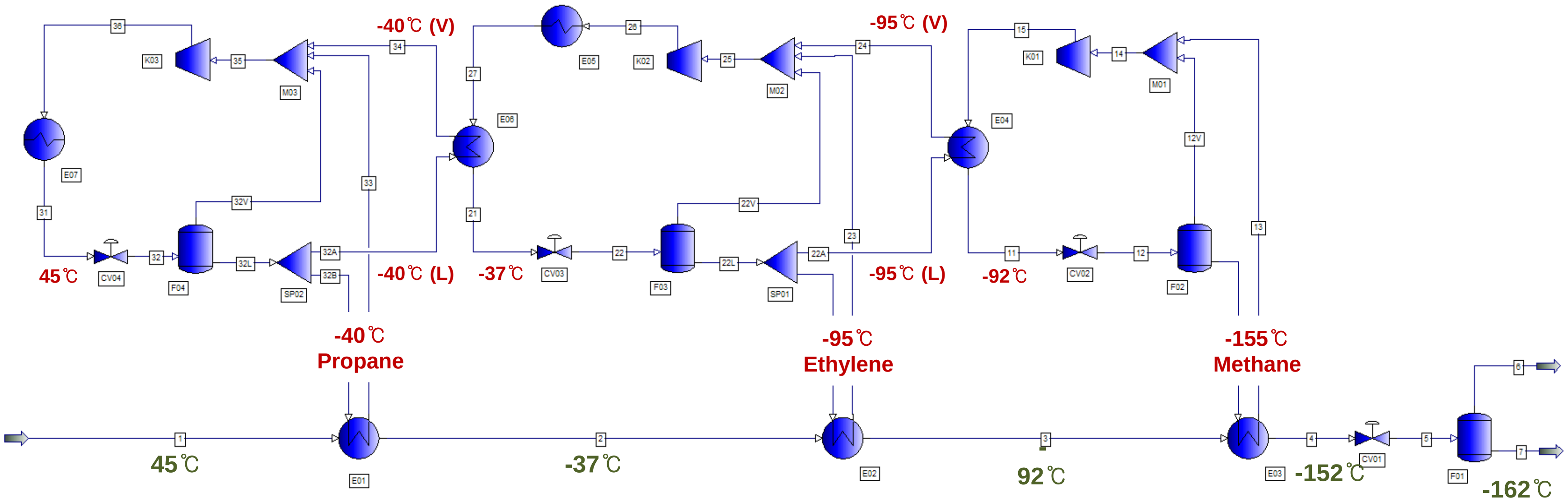
항목	결과
E-101 Heat duty(10^6 Kcal/hr)	24.5583
E-102 Heat duty(10^6 Kcal/hr)	12.1422
E-103 Heat duty(10^6 Kcal/hr)	1.3007
E-104 Heat duty(10^6 Kcal/hr)	17.0705
E-105 Heat duty(10^6 Kcal/hr)	2.6605
E-106 Heat duty(10^6 Kcal/hr)	5.6996
E-107 Heat duty(10^6 Kcal/hr)	30.1835
106번 스트림 온도(℃)	-54.3
X-101 동력(kW)	7,401
C-101 동력(kW)	7,401
C-102 동력(kW)	28,850

4 천연가스 액화공정

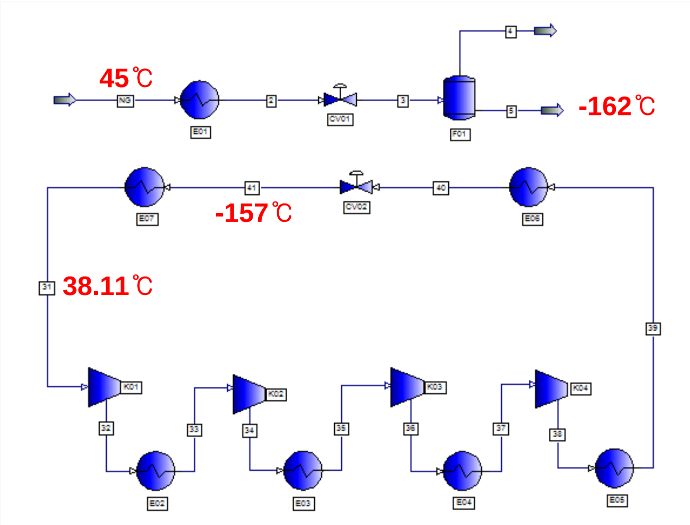
적용한 천연가스의 원료 성분 및 조건

Component	Mole%
Nitrogen	0.22
Methane	91.33
Ethane	5.36
Propane	2.14
I-Butane	0.46
N-Butane	0.47
I-Pentane	0.01
N-Pentane	0.01
Total	100
Content	**Value**
Pressure (barA)	53
Temperature (°C)	45
Flow Rate (kg/hr)	625,000

Cascade 냉동공정 조건들



SMR 냉동공정 조건들



SMR Composition

Component	Mole %
Nitrogen	7.14
Methane	11.91
Ethane	9.52
Propane	71.43
Total Flow (Kg/hr)	**4.2E+06**

SMR input Condition

Stream 31	Value
Temperature (℃)	38.11
Pressure (bar)	1.3

SMR (Single Mixed Refrigerant) 공정 결과

Component	Compressor	Actual Work
MR (C1, C2,C3, N2)	K01	99,255
	K02	98,265
	K03	94,661
	K04	86,503
Total Actual work (kW)		**378,684**

LNG	Flowrate (kg/hr)
Stream5	577,157

Actual Work
0.6561 kW/(kg/hr LNG)

Cascade & SMR 공정 결과

Cascade

Component	Compressor	Actual Work
C1	K01	65,915
C2-	K02	114,073
C3	K03	262,446
Total Actual work (kW)		**442,434**

LNG	Flowrate (kg/hr)
Stream5	577,310

Actual Work
0.7700 kW/(kg/hr LNG)

SMR

Component	Compressor	Actual Work
MR (C1, C2,C3, N2)	K01	99,255
	K02	98,265
	K03	94,661
	K04	86,503
Total Actual work (kW)		**378,684**

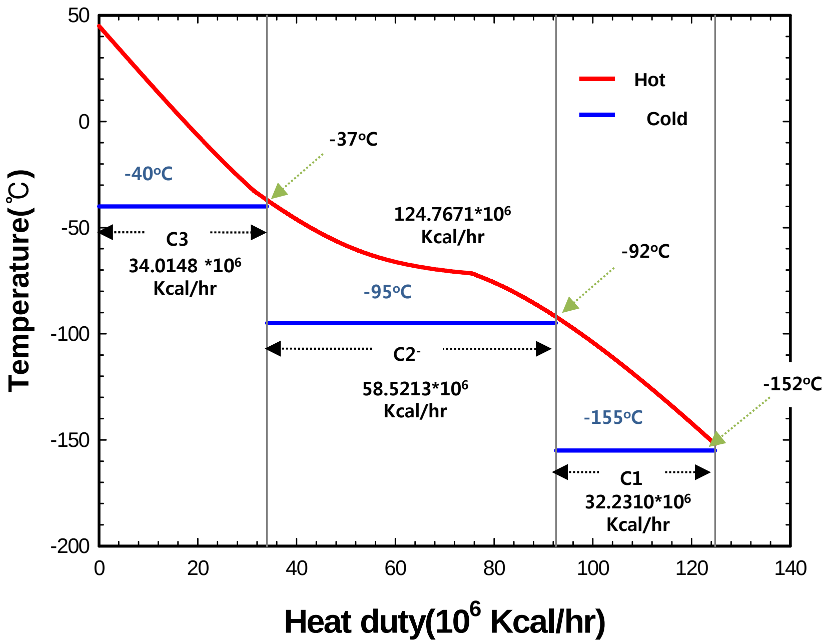
LNG	Flowrate (kg/hr)
Stream5	577,157

Actual Work
0.6561 kW/(kg/hr LNG)

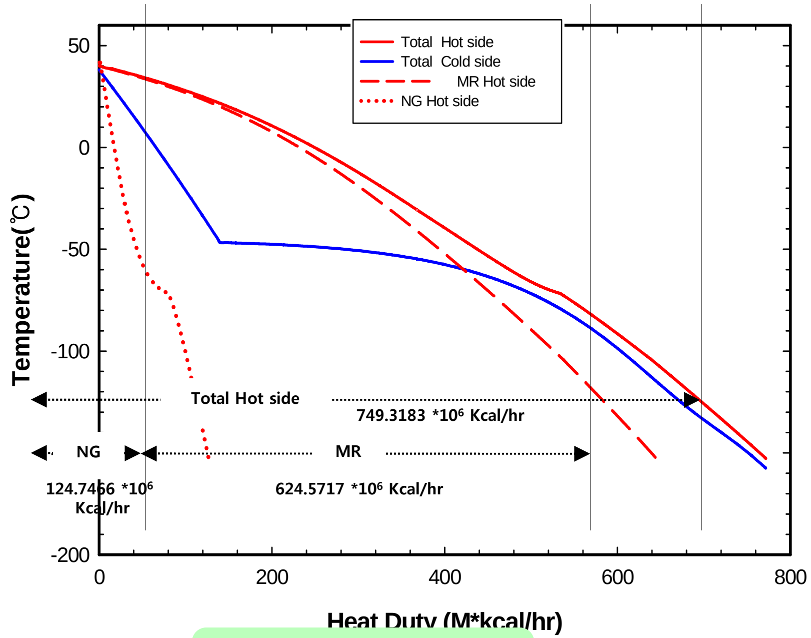
Cascade & SMR Heating Curve 비교

1단공정개요도.JNB
SigmaPlot 10.0 Notebook
63KB

SMR 완성.JNB
SigmaPlot 10.0 Notebook
62KB

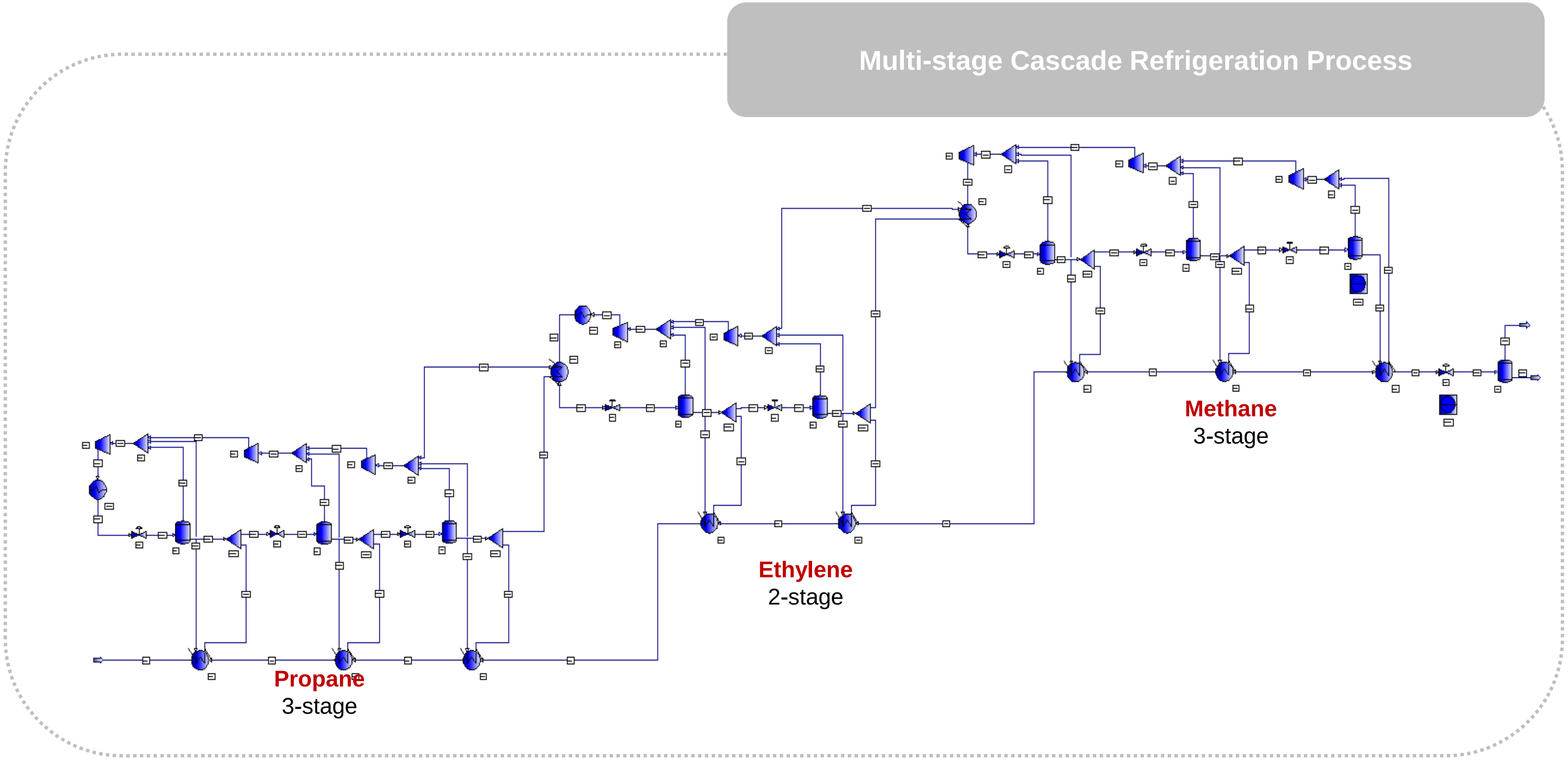


Cascade Process



SMR Process

다단 Cascade 냉동 사이클의 전산모사



- 단순한 프로판 또는 프로필렌 냉동 사이클의 모사보다는 복잡한 냉동 사이클의 전산모사 능력 또한 매우 중요함

THANK YOU