



# SINTESIS PROSES

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## MODUL 2

# PROCESS CREATION

- Several alternatives are being considered, involving several raw materials, the desired products, and several by products and reaction intermediates.
- For these chemicals, basic thermophysical properties are needed, including molecular weight, normal boiling point, freezing point, critical properties, standard enthalpy and Gibbs free energy of formation, and vapor pressures, densities, heat capacities, and latent heats as a function of temperature
- If chemical reactions are involved, some rudimentary information (basic information) concerning the rates of the principal chemical reactions, such as conversion and product distribution as a function of space velocity, temperature, and pressure, is often needed before initiating the process synthesis steps.

# PRELIMINARY PROCESS SYNTHESIS

- Salah satu tantangan terbesar dalam desain proses melibatkan sintesis konfigurasi yang menghasilkan bahan kimia dengan cara yang andal, aman, dan ekonomis, dan pada hasil tinggi dengan sedikit atau tanpa limbah
- Bagian dari proses desain ini, sering disebut sebagai sintesis proses, di mana banyak jenis operasi proses dikonfigurasi ke dalam alur proses.
- Sintesis proses dilakukan setelah alternatif konsep pemrosesan dibuat dan didefinisikan serta penyusunan data pendahuluan.



## PRELIMINARY PROCESS SYNTHESIS

- As the first step in process synthesis, the design team must decide on raw-material and product specifications. These are referred to as states.
- Note that the state selections can be changed later with modifications to the flowsheets.
- To define the state, values of the following conditions are needed:

## CHEMICAL STATE:

- Mass (flow rate)
- Composition (mole or mass fraction of each chemical species of a unique molecular type)
- Phase (solid, liquid, or gas)
- Form, if solid phase (e.g., particle size distribution and particle shape)
- Temperature
- Pressure



**Figure 4.3** Process synthesis problem

## CHEMICAL STATE

When the desired states of these streams have been identified, the problem of process synthesis becomes better defined.

As shown in Figure 4.3, for the production of vinyl chloride, it remains to insert the process operations into the flowsheet.

# PROCESS OPERATION

- Chemical reaction
- Separation of chemical mixtures
- Phase separation
- Change of temperature
- Change of pressure
- Change of phase
- Mixing and splitting of streams or batches
- Operations on solids, such as size reduction and enlargement

# PROCESS OPERATION

## ■ Chemical reaction

Chemical reaction operations are at the heart of many chemical processes. The positioning of the reaction operations in the flowsheet involves many considerations, including the degree of conversion, reaction rates, competing side reactions, and the existence of reactions in the reverse direction (which can result in constraints on the conversion at equilibrium).

## ■ Separation of chemical mixtures

- Separation operations appear in almost every process flowsheet. They are needed whenever there is a difference between the desired composition of a product or an intermediate stream and the composition of its source, which is either a feed or an intermediate stream. Separation operations are inserted when the raw materials contain impurities that need to be removed before further processing, such as in reactors, and when products, byproducts, and unreacted raw materials coexist in a reactor effluent stream.
- The choice of separation operations depends first on the phase of the mixture and second on the differences in the physical properties of the chemical species involved.

# PROCESS OPERATION

- **Phase separation**

Many separation operations require phase-separation operations, which may be accomplished by vessels called flash drums for vapor–liquid separation, by decanters for liquid–liquid separation, and by filters and centrifuges for liquid–solid separation.

- **Change of temperature**

There are often differences in the temperatures of the streams that enter or leave the process or that enter or leave adjacent process operations, such as reaction and separation operations. Often a process stream needs to be heated or cooled from its source temperature to its target temperature. This is best accomplished through heat exchange with other process streams that have complementary cooling and heating demands.

- **Change of pressure**

Pressure change operations will be needed to decrease or increase the pressure of the feed to the particular operation. In fact, for processes that have high power demands, usually for gas compression, there is often an opportunity to obtain much of the power through integration with a source of power, such as turbines or expanders, which are pressure-reduction devices.

# PROCESS OPERATION

- Change of phase

Often there are significant differences in the phases that exit from one process operation and enter another. For example, hot effluent gases from a reactor are condensed, or partially condensed, often before entering a separation operation, such as a vapor–liquid separator (e.g., a flash vessel or a distillation tower).

- Mixing and splitting of streams or batches

The mixing operation is often necessary to combine two or more streams and is inserted when chemicals are recycled and when it is necessary to blend two or more streams to achieve a product specification.

- Operations on solids, such as size reduction and enlargement

# PROCESS SYNTHESIS

**Reliable**

**Safe**

**Economical Manner**

**High Yield**



# PROCESS SYNTHESIS

- Given the states of the raw-material and product streams, process synthesis involves the selection of processing operations to convert the raw materials to products.
- Each operation can be viewed as having a role in eliminating one or more of the property differences between the raw materials and the desired products.
- As each operation is inserted into a flowsheet, the effluent streams from the new operation are closer to those of the required products.

1

## Chemical reactions

Eliminate differences in molecular types

2

## Mixing

Distribute the chemicals by matching sources and sinks

3

## Separation

Eliminate differences in composition

4

## Temperature, pressure, and phase change

Eliminate differences in temperature, pressure, and phase

5

## Integrate Task

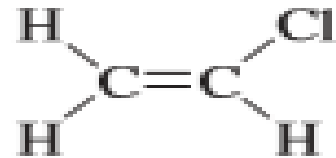
Combine operations into unit processes

SYNTHESIS STEP

# EXAMPLE OF PROCESS SYNTHESIS: MANUFACTURE OF VINYL CHLORIDE

## Example of Process Synthesis: Manufacture of Vinyl Chloride

Consider the need to manufacture vinyl chloride,



a monomer intermediate for the production of polyvinyl chloride,



## STEP I

# ELIMINATE DIFFERENCES IN MOLECULAR TYPE

- Alternatif Reactions
  - Direct Chlorination of Ethylene
  - Hydrochlorination of Acetylene
  - Thermal Cracking of Dichloroethane from Chlorination of Ethylene
  - Thermal Cracking of Dichloroethane from Oxychlorination of Ethylene
  - Balanced Process for Chlorination of Ethylene

# KOMPARASI SETIAP ALTERNATIF BERDASARKAN ASUMSI BIAYA BAHAN BAKU TERHADAP HARGA PRODUK

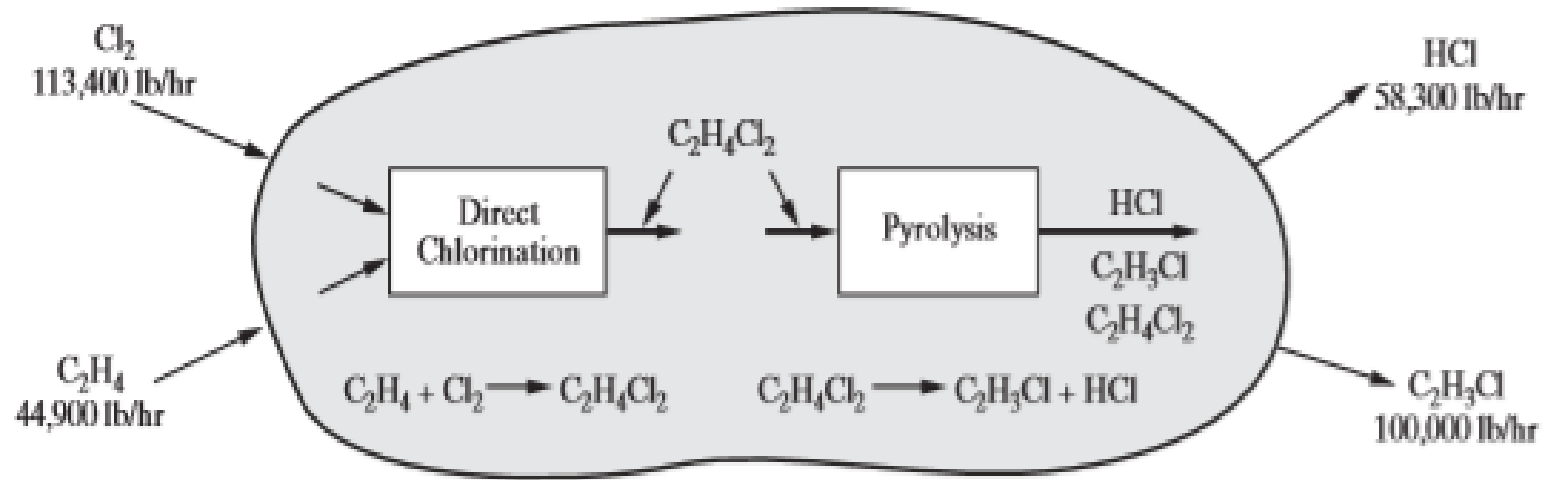
**Table 4.2** Assumed Cost of Chemicals Purchased or Sold in Bulk Quantities

Chemical	Cost (cents/lb)
Ethylene	30
Acetylene	80
Chlorine	18
Vinyl chloride	35
Hydrogen chloride	25
Water	0
Oxygen (air)	0

**Table 4.3** Gross Profit for Production of Vinyl Chloride (Based on Chemical Prices in Table 4.2)

Reaction path	Overall reaction	Gross profit (cents/lb of vinyl chloride)
2	$C_2H_2 + HCl = C_2H_3Cl$	-16.00
3	$C_2H_4 + Cl_2 = C_2H_3Cl + HCl$	15.69
4	$C_2H_4 + HCl + \frac{1}{2}O_2 = C_2H_3Cl + H_2O$	6.96
5	$2C_2H_4 + Cl_2 + \frac{1}{2}O_2 = 2C_2H_3Cl + H_2O$	11.32

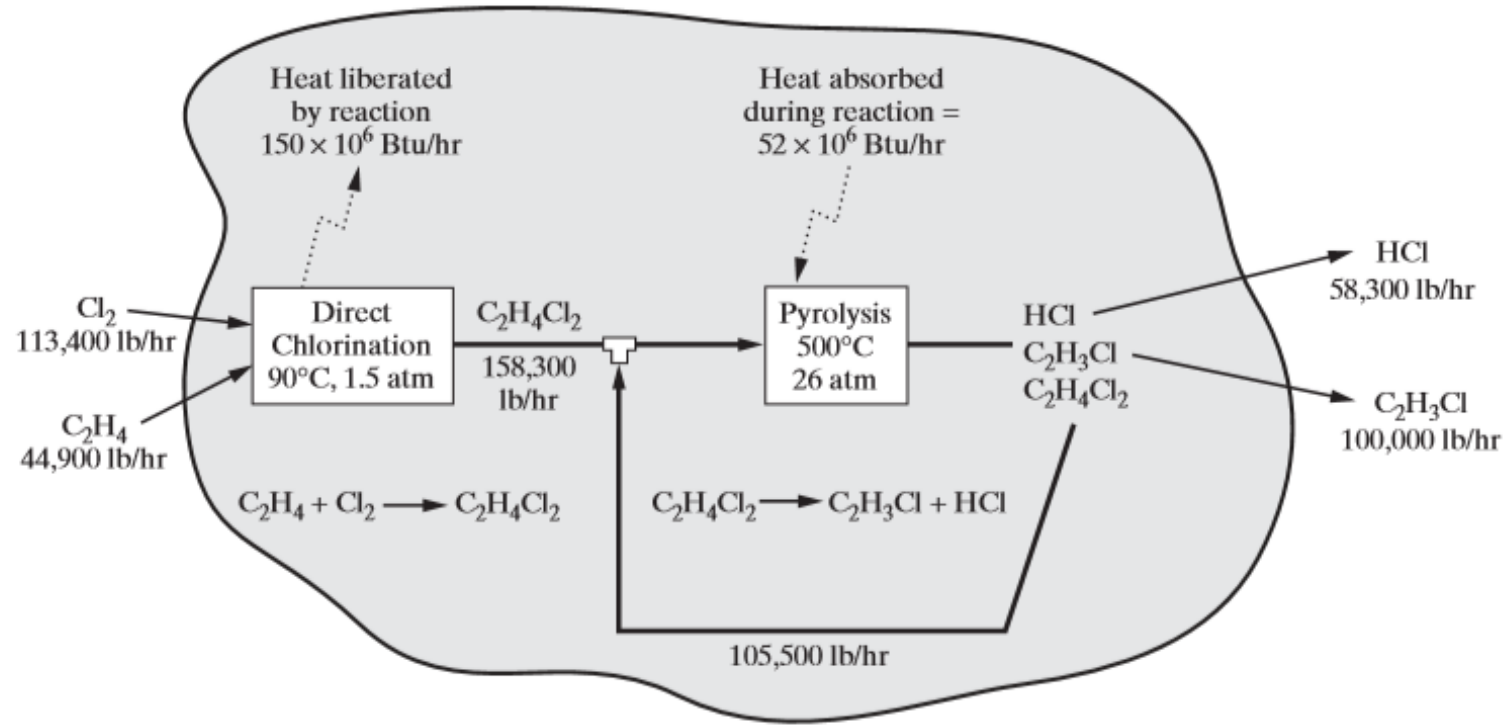
# THERMAL CRACKING OF DICHLOROETHANE FROM THE CHLORINATION OF ETHYLENE AS THE ALTERNATIVE PROCESS



**Figure 4.4** Reaction operations for the thermal cracking of dichloroethane from the chlorination of ethylene (reaction path 3)

# STEP 2

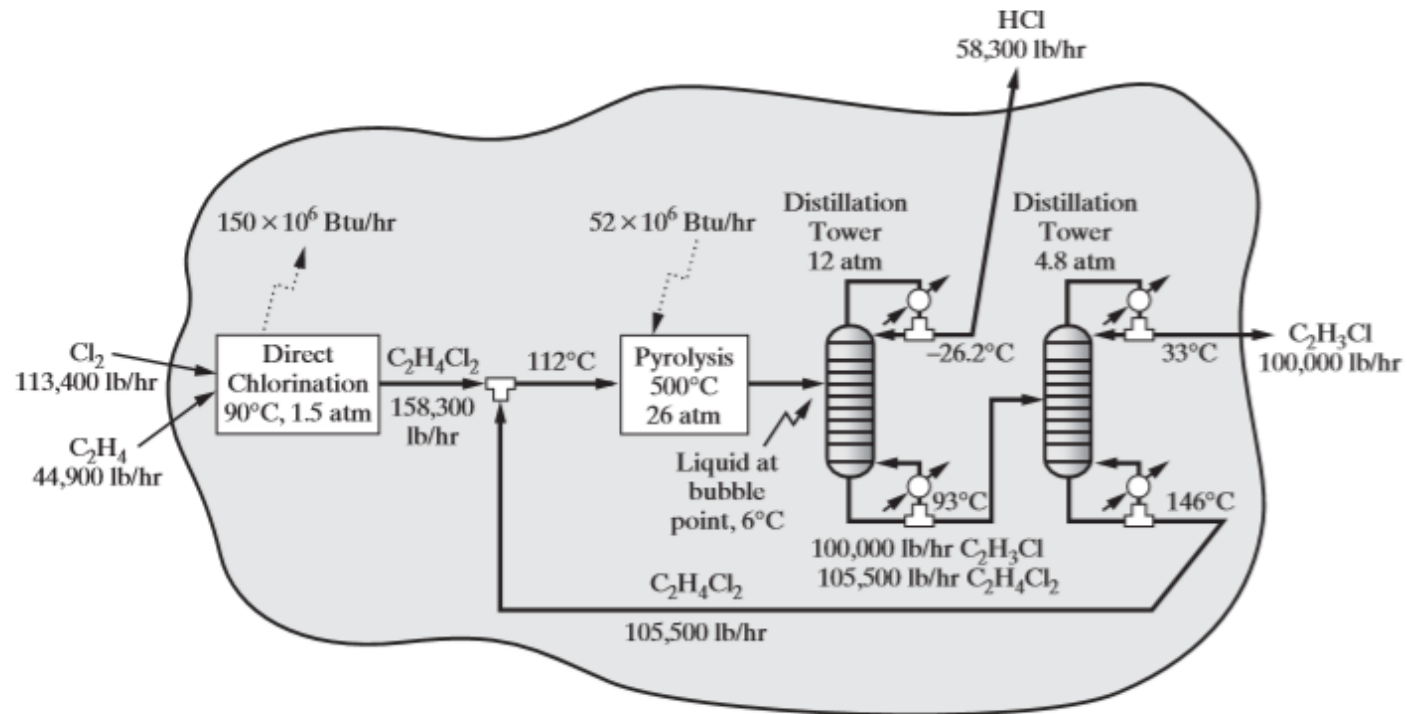
## DISTRIBUTE THE CHEMICALS



**Figure 4.5** Flowsheet showing a distribution of chemicals for thermal cracking of dichloroethane from chlorination of ethylene (reaction path 3)

# STEP 3

## ELIMINATE DIFFERENCES IN COMPOSITION



**Figure 4.6** Flowsheet including the separation operations for the vinyl-chloride process

# STEP 4

## ELIMINATE DIFFERENCES IN TEMPERATURE, PRESSURE, AND PHASE

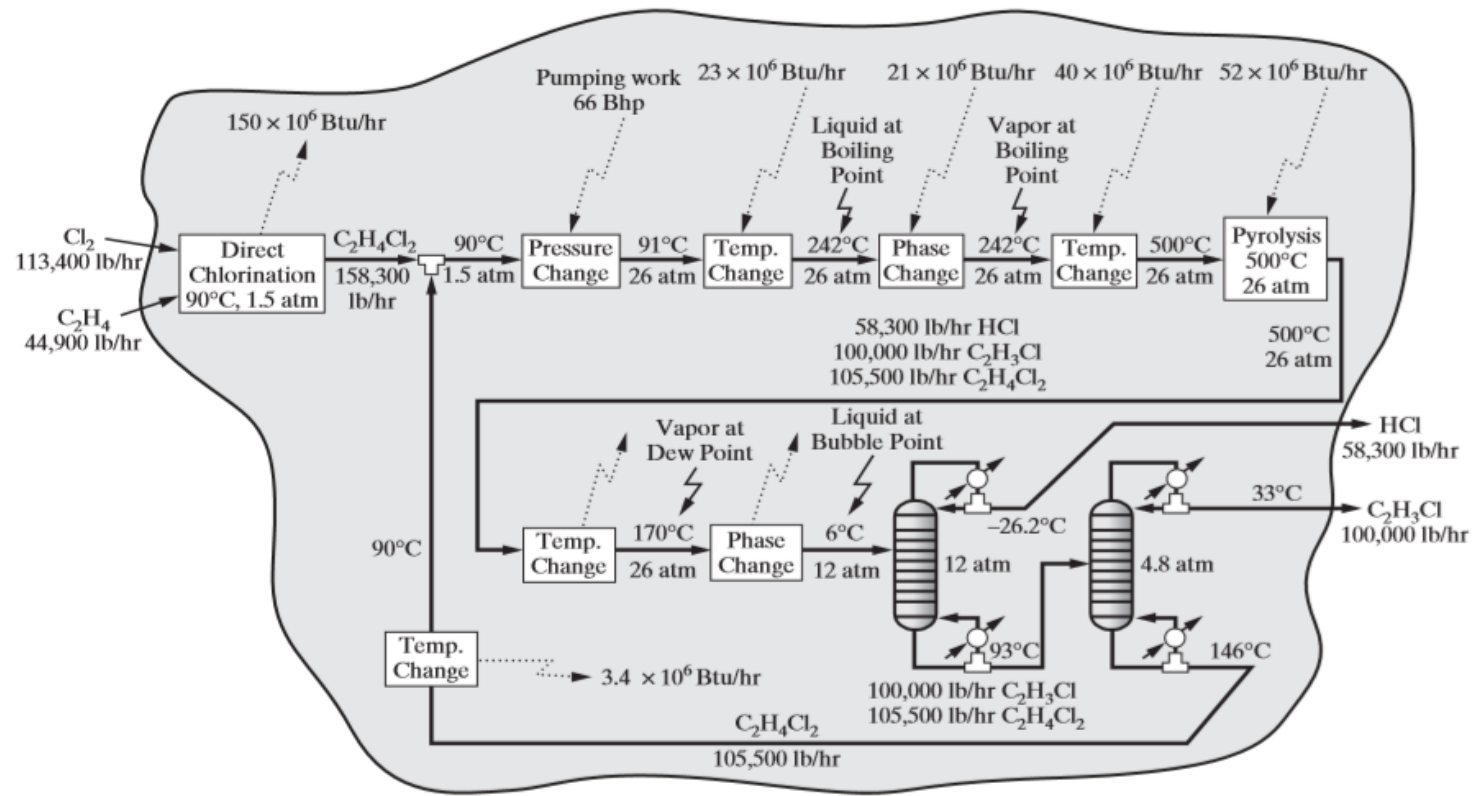
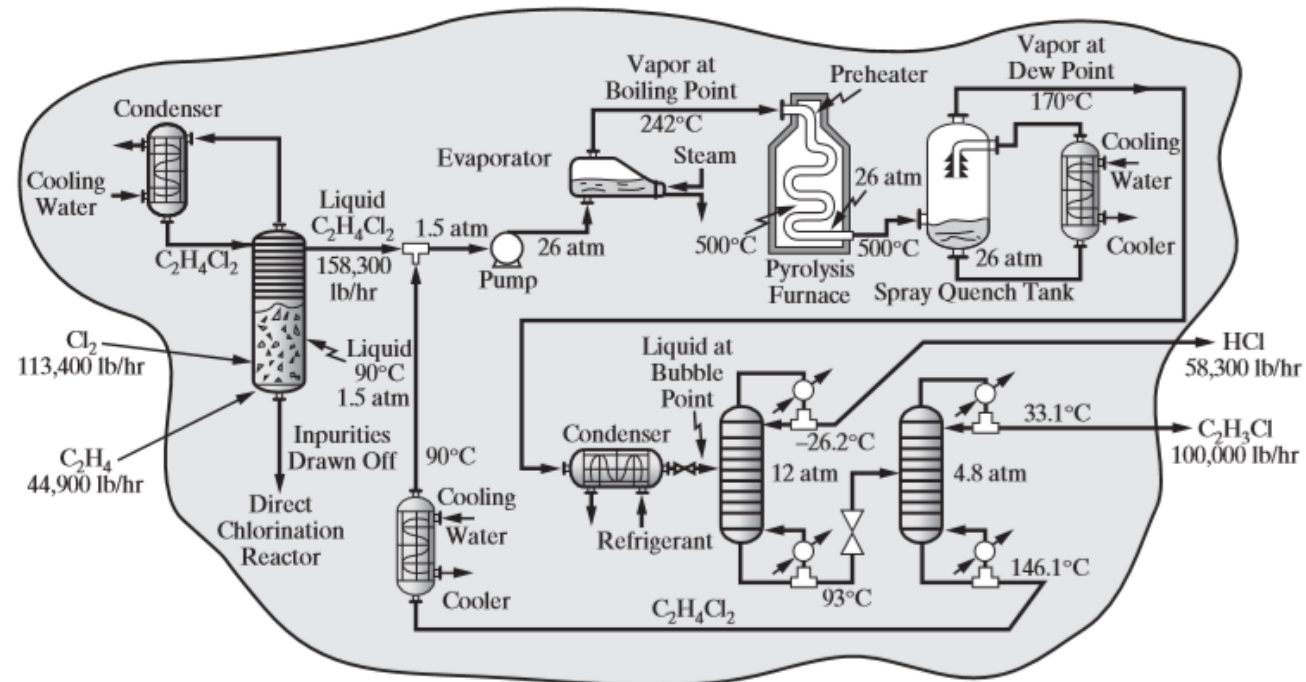


Figure 4.7 Flowsheet with temperature-, pressure-, and phase-change operations in the vinyl-chloride process

# STEP 5 TASK INTEGRATION



**Figure 4.8** Flowsheet showing task integration for the vinyl-chloride process



THANK YOU!