CHAPTER 3: TRACING CHEMICALS THROUGH THE PROCESS FLOW DIAGRAM

Why?

→ How does the process work?
→ What are T, P, composition?
→ Problem definition (in unit operations)

BEFORE GETTING STARTED, TWO UNITS OF CONVENIENCE:

ADIABATIC MIXER

- Single outlet
- Uniform T, P, composition in outlet

ADIABATIC SPLITTER

- All outlet streams same T, P, composition
- Flowrates can be different
USEFUL ADDITION ON PFD TO
COMBINE AND SPLIT STREAMS
(IN REALITY, JUST PIPING)

TRACING PRIMARY PATHS FOR CHEMICALS

→ PRIMARY CHEMICALS ARE ASSOCIATED
   WITH REACTIONS

→ PATHS BETWEEN REACTORS AND PROCESS
   BOUNDARIES ARE PRIMARY FLOW PATHS

1) REACTANTS
   → Trace forward toward reactor

2) PRODUCTS
   → Trace backward toward reactor

→ EXAMPLES 3.1 & 3.2
**Figure 1.3** Skeleton Process Flow Diagram (PFD) for the Production of Benzene via the Hydrodealkylation of Toluene

**EXAMPLE 3.1:**

a) Primary pathway for toluene: feed to reactor  
b) Primary pathway for benzene: reactor to product

**EXAMPLE 3.2:**

a) Primary pathway for hydrogen: feed to reactor  
b) Primary pathway for methane: reactor to product
RECYCLE AND BYPASS STREAMS:

1) LOOK FOR FLOW LOOPS
   ⇒ Bypass
   OR
   ⇒ Recycle

2) COMPLETE LOOPS RETURNING TO ORIGIN
   ⇒ RECYCLE

3) OTHERWISE
   ⇒ BYPASS

4) EQUIPMENT WILL CONTAIN RECYCLE LOOPS AS WELL

EXAMPLE 3.3:
Identify all recycle and bypass loops in the hydrodealkylation process shown in Figure 1.3.
Figure 1.3  Skeleton Process Flow Diagram (PFD) for the Production of Benzene via the Hydrodealkylation of Toluene

RECYCLE: (5)

BYPASS: (1)
Provide preliminary identification of the important chemical species in each of the three recycle streams identified in Example 3.3.

**Figure E3.3(a)** Identification of Toluene Recycle Loop in Toluene Hydrodealkylation PFD

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**Toluene**  \(\rightarrow\) **WHY?**

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**Fuel Gas**  \(\rightarrow\) **WHY?**
**Limitations**

- **V-101**: Toluene Reactor
- **P-101A/B**: Toluene Feed Pumps
- **E-101**: Toluene Feed Heater
- **H-101**: Preheater
- **R-101**: Toluene Reactor
- **C-101A/B**: Recycle Gas Compressor
- **E-102**: Reactor Effluent Cooler
- **V-102**: High Pressure Phase Separation
- **V-103**: Low Pressure Phase Separation
- **E-103**: Benzene Feed Heater
- **E-106**: Benzene Reboiler
- **T-101**: Benzene Column
- **E-104**: Benzene Condenser Drum
- **V-104**: Reflux
- **P-102A/B**: Product Pumps
- **E-105**: Product Cooler

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**Figure 1.3** Skeleton Process Flow Diagram (PFD) for the Production of Benzene via the Hydrodealkylation of Toluene

→ **NOT ALL INFORMATION**

→ **USE OTHER RESOURCES**

( **EQUIPMENT TABLE + STREAM TABLE** )

→ **FUNCTION**

**T, P, COMPOSITION**