Lecture Fifteen

(MATERIAL BALANCES FOR PROCESSES INVOLVING BYPASS AND PURGE WITH AND WITH OUT CHEMICAL REACTION)

In this Lecture we discuss two additional commonly type of process streams material balances involving **bypass** (الإلتفاف) and **Purge** (النزف). **bypass** and **Purge** will also be explained along with the industrial uses of material balances.

Bypass and purge streams are commonly used in the design of chemical processes around the reaction units. Reactor as well as in unit operations such as drying, distillation, and extraction units. Typical material balance calculations an processes involving such streams are given in this lecture.

1. Bypass Stream

2. Purge Stream

Your Objectives in Studying this Lecture are :

* Draw a flow diagram or sketch for problems involving recycle.
* Apply the 10-step strategy to solve steady-state problems (with and without chemical reaction) involving bypass and purge streams.
* Explain the purpose of a bypass stream, and a purge stream.

1. Bypass stream

a stream that skips one or more stages of the process and goes directly to another downstream stage. (Figure 1). A bypass stream can be used to control the composition of a final exit stream from a unit by mixing the bypass stream and the unit exit stream in suitable proportions to obtain the desired final composition. or to make a relative small change in the feed stream.

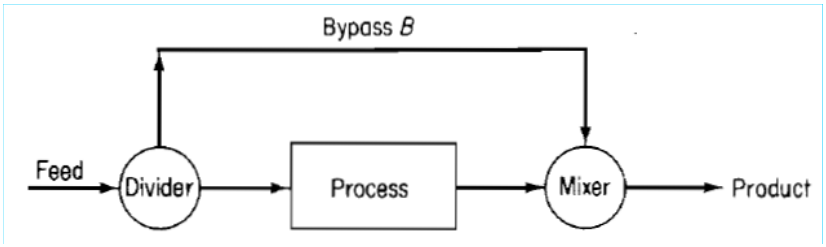


Figure.1 A process with a bypass stream.

Some of important applications of bypass stream are as follow

1. Pumping of liquid from a storage tank by a more efficient pump of high horsepower to a small process unit at desired lower flow rate.
2. Dissolution of caustic soda in water by a two–step process due to the very high heat of dissolution .
3. Separation of mixtures by a more efficient distillation column, so that a bypass stream is used to control the composition of the final product at the desired value.

2. Purge stream

a stream bled off from the process to remove an accumulation of inert or unwanted material that might otherwise build up in the recycle stream. Or it is a fraction of the recycle stream (with the same composition) that is remove out the process to prevent accumulation of inert materials (that are not involve in the reaction) in the recycle stream. (Figure 2).

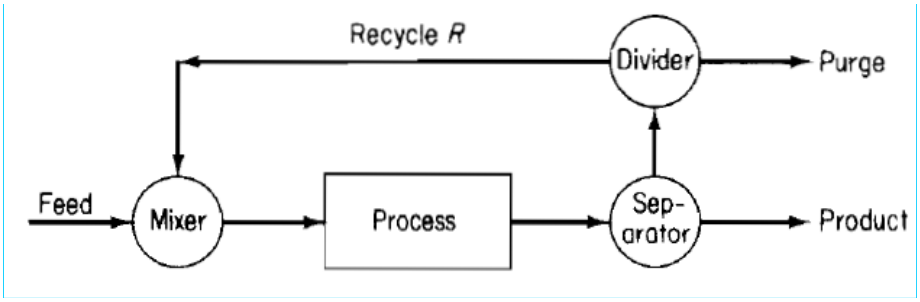


Figure.2 A process with a recycle stream with purge.

Some of important applications of bypass stream are as follow

Look at Figure 3 for an example of a process involving recycle with a purge stream.

Note how in the steady state the argon concentration is different in each successive recycle stream so that **1% argon** occurs in the feed stream while **25% argon** occurs in the third recycle and purge stream. For effective operation, the **Ar** concentration cannot be allowed to increase further. Remember that the process operates continuously in the steady state so that the **Ar** concentration is constant in each individual recycle stream.

Similarly, purge stream is used in the process of acetaldehyde production by oxidation of ethylene according to the reaction ;

$$2C_2H_4 + O_2 \longrightarrow 2C_2H_4O$$

The feed to the process consists of ethylene and air and the conversion of C_2H_4 is about 50%, hence, nitrogen input with air must be removed by purge stream in order to return unreacted C_2H_4 as a recycle stream

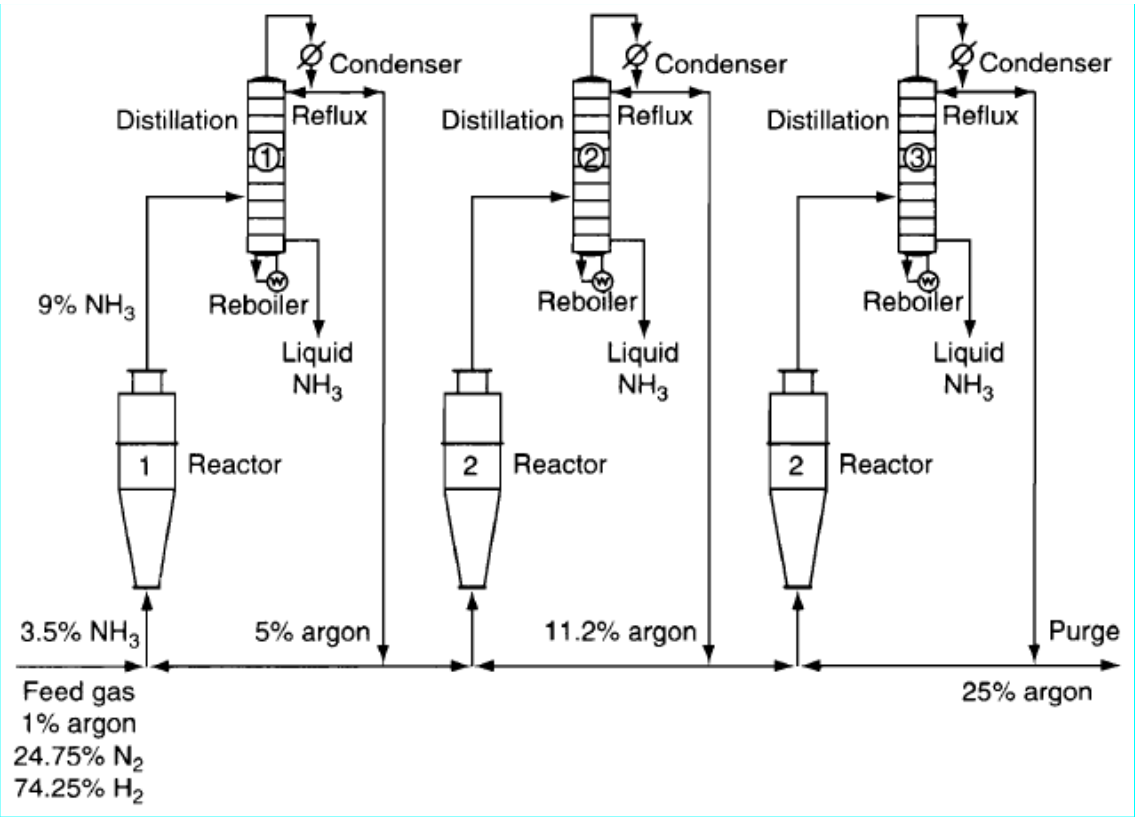


Figure.3 A process to manufacture ammonia that involves three reactors and three distillation columns. Note the stepwise rise in the concentration of Ar in the recycle streams.

EXAMPLE -1 *Bypass Calculation*

In the feedstock preparation section of a plant manufacturing natural gasoline, isopentane is removed from butane-free gasoline. Assume for purposes of simplification that the process and components are as shown in **Figure P1**. What fraction of the butane-free gasoline is passed through the isopentane tower? Detailed steps will not be listed in the analysis and solution of this problem. The process is in the steady state and no reaction occurs.

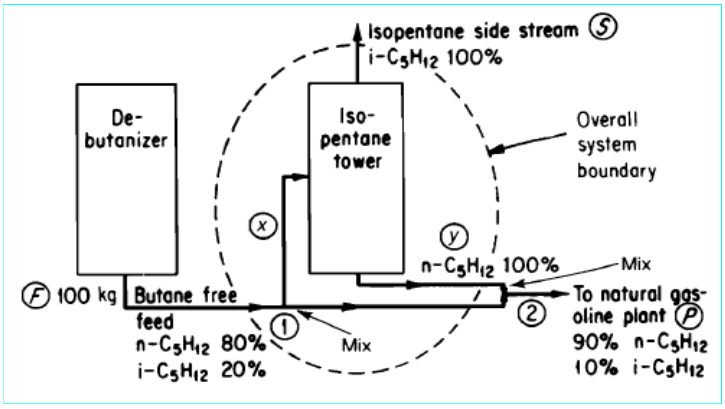


Figure.P1

Solution:

By examining the flow diagram you can see that part of the butane-free gasoline bypasses the isopentane tower and proceeds to the next stage in the natural gasoline plant. All the compositions (the streams are liquid) are known. Select a basis: 100 kg feed

What kind of balances can you write for this process? You can write the following:

a. *Overall balances* (each stream is designated by the letter *F*, *S*, or *P* with the units being kg)

Total material balance:

$$\frac{In}{100} = \frac{Out}{S + P} \tag{a}$$

Component balance for n-C_5 *(tie component)*

$$\frac{In}{100(0.80)} = \frac{Out}{S(0) + P(0.90)} \tag{b}$$

Consequently,

$$P = 100\left(\frac{0.80}{0.90}\right) = 88.9 \text{ kg}$$

$$S = 100 - 88.9 = 11.1 \text{ kg}$$

The overall balances will not tell you the fraction of the feed going to the isopentane tower. For this calculation you need another balance.

b. *Balance around isopentane tower:* Let x be the kg of butane-free gas going to the isopentane tower, and y be the kg of the *n*-C_5H_{12} stream leaving the isopentane tower.

Total material balance:

$$\frac{In}{x} = \frac{Out}{11.1 + y} \tag{c}$$

Component balance for n-C_5 *(a tie component)*:

$$x(0.80) = y \tag{d}$$

Consequently, combining (c) and (d) yields

$x = 55.5$ kg, or the desired fraction is 0.55.

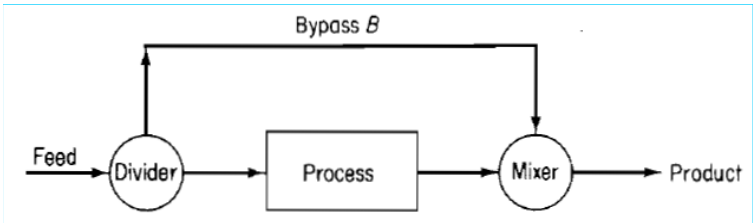
Lecture Fifteen / Tutorials

(MATERIAL BALANCES FOR PROCESSES INVOLVING BYPASS AND PURGE WITH AND WITH OUT CHEMICAL REACTION)

1. Explain what bypass means in words and also by a diagram.

Solution:

a stream that skips one or more stages of the process and goes directly to another downstream stage.



2. Answer the following questions true or false:

a. Purge is used to maintain a concentration of a minor component of a process stream below some set point so that it does not accumulate in the process.
b. Bypassing means that a process stream enters the process in advance of the feed to the process.
c. A trace component in a stream or produced in a reactor has negligible effect on the overall material balance when recycle occurs.

Solution:

a. True.
b. False.
c. False.

3. Is the waste stream the same as a purge stream in a process?

Solution:

Not necessarily. A purge is considered a stream that removes a small amount of a component to prevent it from building up in the system. A waste stream usually contains a large amount of a component.