

Chapter 4 MATERIAL BALANCE

$$\begin{aligned} \text{Amount of polystyrene produced per day} &= 250 \text{ TPD} \\ &= 250 \times 10^3 / 24 \\ &= 10416.67 \text{ Kg/hr} \end{aligned}$$

The key to successful production of polystyrene is the reaction. The ratio of materials to be used is a compromise of literature values. All the authors discussing suspension polymerization say the reaction should be allowed to go to completion (removing and recycling the unreacted styrene would be expensive).

It will be assumed that 99.8% of the styrene is reacted and this can be accomplished by using an average of the temperatures and cycle time given.

Temperature of reaction = 90-95°C

Cycle time of reactor = 5.5 hrs.

Reactor:

Input to the reactor: (unit ratios are obtained from literature):

$$\begin{aligned} \text{Styrene} &= 1.032 \text{ kg styrene/kg polystyrene} &= 1.032 \times 10416.67 \\ & &= 10750 \text{ kg.} \end{aligned}$$

$$\begin{aligned} \text{Water} &= 2.0 \text{ kg water/kg polystyrene} &= 2.0 \times 10416.67 \\ & &= 20833.34 \text{ kg.} \end{aligned}$$

$$\begin{aligned} \text{Tricalcium phosphate} &= 0.005 \text{ kg tricalcium phosphate/kg polystyrene} \\ & &= 0.005 \times 10416.67 \\ & &= 52.08 \text{ kg.} \end{aligned}$$

$$\begin{aligned} \text{Dodecylbenzene sulphonate} &= 0.00006 \text{ kg dodecylbenzene sulphonate/kg polystyrene} \\ & &= 0.00006 \times 10416.67 \\ & &= 0.625 \text{ kg.} \end{aligned}$$

$$\begin{aligned} \text{Benzoyl peroxide} &= 0.0025 \text{ kg benzoyl peroxide/kg polystyrene} \\ & &= 0.0025 \times 10416.67 \\ & &= 26.04 \text{ kg.} \end{aligned}$$

$$\begin{aligned} \text{Miscellaneous} &= 0.004 (\text{styrene } 99.6\% \text{ pure}) (\text{unit ratio}) = 0.004 \times 10416.67 \\ & &= 41.67 \text{ kg.} \end{aligned}$$

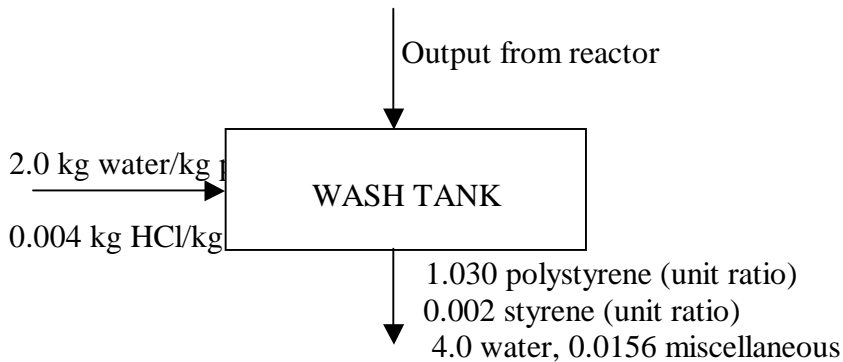
$$\text{Total input to reactor} = 31703.75 \text{ kg.}$$

Output from the reactor: (unit ratios are obtained from literature: Baasel)

$$\text{Polystyrene} = 1.030 \text{ kg polystyrene / kg of polystyrene} = 1.030 \times 10416.67$$

Styrene = 0.002 kg styrene/kg polystyrene = 10729.17kg.
 = 0.002*10416.67
 = 20.83kg
 Water = 2.0 kg water/kg polystyrene = 2.0*10416.67
 = 20833.34kg.
 Miscellaneous = 0.0116 kg /kg polystyrene = 0.0116*10416.67
 =120.83kg.
 Total output from reactor = 31704kg.

Wash tank:



Input to wash tank:

Output from reactor = (1.030+0.002+2.0+0.0116)*10416.67= 31704kg.
 Water =2.0 kg water/ kg polystyrene
 =2.0*10426.67
 =20833.34kg.
 Hydrochloric acid = 0.004 kg HCl/ kg polystyrene
 = 0.004*10416.67
 = 41.67kg.

Total input to wash tank = 52579.01kg.

Output from wash tank:

Polystyrene = 1.030 kg polystyrene/ kg polystyrene desired
 =1.030*10416.67 = 10729.17kg

Styrene = 0.002 kg styrene/kg polystyrene

= 0.002*10416.67

= 20.83kg.

Water = 4.0 kg water/ kg polystyrene

= 4.0*10416.67

= 41666.68kg.

Miscellaneous = 0.0156 kg/kg of polystyrene

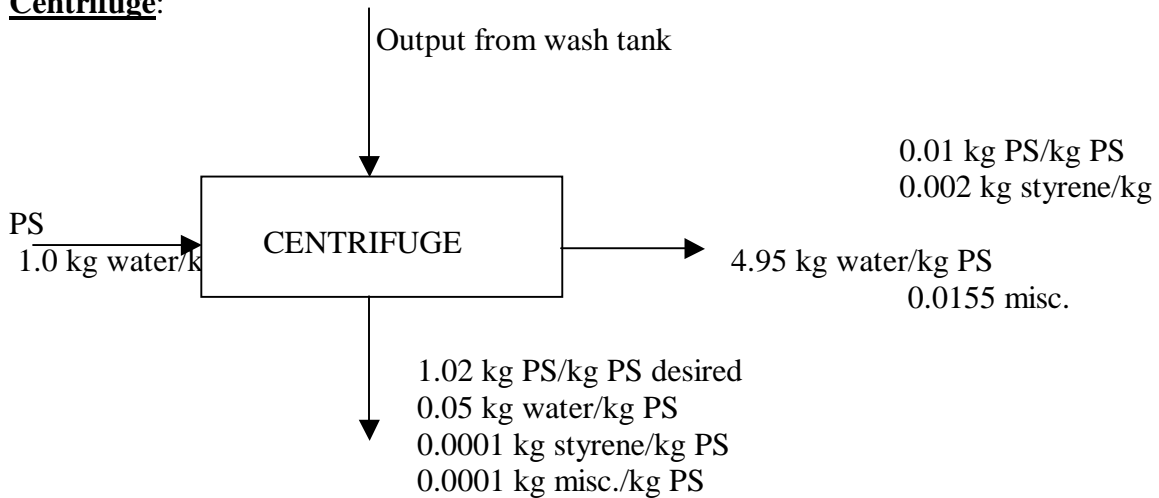
= 0.0156*10416.67

= 162.5kg

Total output from wash tank = 10729+ 20.83+41666.68+162.5

= 52579.18kg

Centrifuge:



Input to the centrifuge:

Output from wash tank = 52579.18kg

Water = 1.0 kg water/kg polystyrene

=10416.67kg water.

Output from centrifuge:

The output from centrifuge comprises of two layers. One is the desired and the other is bad product.

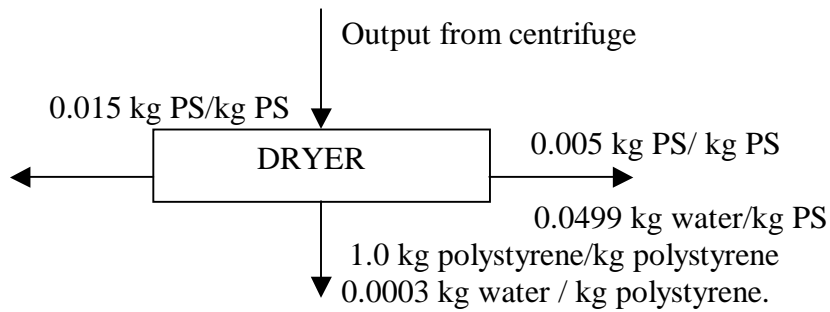
Desired product composition:

Polystyrene	= 1.02 kg polystyrene/kg of desired polystyrene
	= $1.02 * 10416.67$
	= 10625kg
Styrene	= 0.0001 kg styrene/kg polystyrene
	= $0.0001 * 10416.67$
	= 1.0417 kg.
Water	= 0.05 kg water/ kg polystyrene
	= $0.05 * 10416.67$
	= 520.83kg
Miscellaneous	= 0.0001 kg/ kg polystyrene
	= $0.0001 * 10416.67$
	= 1.0417kg

Bad product composition:

Polystyrene	= 0.01kg polystyrene/kg polystyrene
	= $0.01 * 10416.67$
	= 104.17kg
Styrene	= 0.002 kg styrene /kg polystyrene
	= $0.002 * 10416.67$
	= 20.833kg
Water	= 4.95 kg water / kg polystyrene
	= $4.95 * 10416.67 = 51562.52\text{kg}$
Miscellaneous	= 0.0155 kg/ kg polystyrene
	= $0.0155 * 10416.67$
	= 161.98kg.

Dryer:



Input to the dryer:

Output from the centrifuge = 11148.96kg

Output from the dryer:

Output from dryer comprises of three parts;

1. Desired polystyrene with composition:

Polystyrene = 1.0 kg/kg polystyrene
 = 10416.67 kg of polystyrene.

Water = 0.0003 kg/kg polystyrene
 = 0.0003*10416.67
 = 3.125kg

2. Product with;

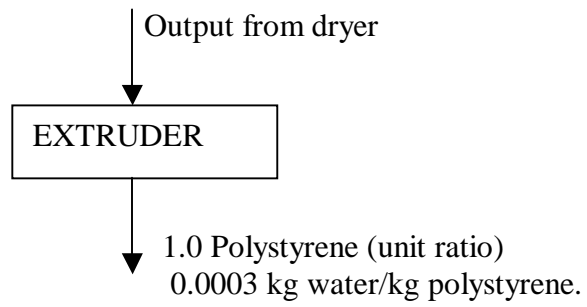
Polystyrene = 0.005 kg/kg polystyrene
 = 0.005*10416.67
 = 52.083kg

Water = 0.0499kg/kg polystyrene
 = 0.0499*10416.67
 = 519.79kg

3. Bad product obtained has a composition;

Polystyrene = 0.015 kg/kg polystyrene
 = 0.015*10416.67
 = 156.25kg

Extruder:



Input to extruder = output from dryer
= 10419.795kg
Output from extruder = 10419.795kg