

A wet paper pulp contains 71 wt% water. After drying, it is found that 60 wt% of the original water has been removed. What is the composition of the dried pulp?

- $\dot{m}_1 \rightarrow$  $\dot{m}_2$
 $X_{w1} = .71$ $X_{w2} = 1$
 $X_{p1} = .29$ $\dot{m}_{w3}$
 $\dot{m}_{p3}$

Assume basis of 100 kg/hr

2. DOF Unknowns = $\dot{m}_2, \dot{m}_{w3}, \dot{m}_{p3} = 3$
 Balances = # species = 2
 Add'l eqns $\Rightarrow \dot{m}_2 = 0.6 \dot{m}_{w1} = \underline{1}$
 DOF = 0

- $$\dot{m}_1 = \dot{m}_2 + \dot{m}_3 \quad (i)$$

$$\dot{m}_{w_1} = \dot{m}_{w_2} + \dot{m}_{w_3} \quad (\text{ii})$$

also $m_{w2} = .6 m_{w1}$ (iii)

4. Simplify $\dot{m}_{w_1} = (.71)(100 \text{ kg/hr}) = 71 \text{ kg H}_2\text{O/hr}$

$$\dot{m}_{w_2} = (0.6)(71 \text{ kg/hr}) = 42.6 \text{ kg H}_2\text{O/hr}$$

So $\dot{m}_{w3} = \dot{m}_{w1} - \dot{m}_{w2} = 71 - 42.6 = 28.4 \text{ kg H}_2\text{O/hr}$

Then use total mass balance (i)

$$100 \text{ kg/hr} = 42.6 \text{ kg/hr} + m_3$$

$$\dot{m}_3 = 57.4 \text{ kg/hr}$$

$$m_{p3} = 57.4 - 28.4 = 29 \text{ kg/hr}$$

$$X_{w3} = 28.4 / 57.4 = 0.495$$

$$X_{p3} = 1 - 0.495 = 0.505$$

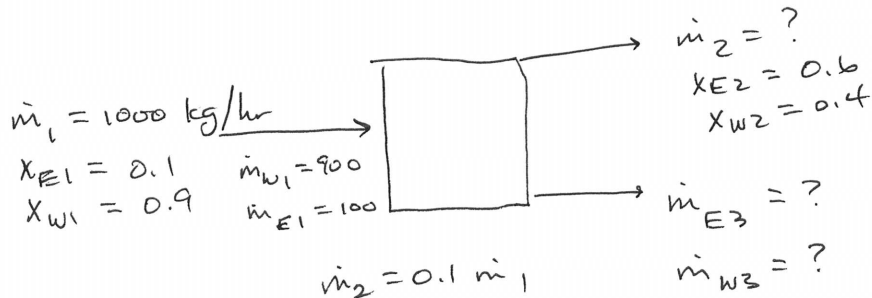
$w_3 =$

$$X_{p,3} =$$

Example 2 Distillation

A mixture containing 10 % EtOH and 90% H₂O by weight is fed to a distillation column at the rate of 1000 kg/h. The distillate contains 60 wt% EtOH and is produced at a rate 1/10th that of the feed. What is the composition and flow rate of the bottoms?

1. Draw Picture



2. DOF Unknowns: $\dot{m}_2, \dot{m}_{E3}, \dot{m}_{W3} = 3$
 balances = # of species = 2
 other eqns = 1

 DOF = 0

3. Write balance equations and additional relationships

Relation $\dot{m}_2 = 0.1 \dot{m}_1 = 100 \text{ kg/hr}$

Total mass $\dot{m}_1 = \dot{m}_2 + \dot{m}_3$, so $\dot{m}_3 = 1000 - 100 = 900 \text{ kg/hr}$

Ethanol balance $\dot{m}_{E1} = \dot{m}_{E2} + \dot{m}_{E3}$

$$100 \frac{\text{kg}}{\text{hr}} = 60 \frac{\text{kg}}{\text{hr}} + \dot{m}_{E3} \Rightarrow \dot{m}_{E3} = 40 \text{ kg/hr}$$

4. Simplify

$$\dot{m}_3 = \dot{m}_{E3} + \dot{m}_{W3} \Rightarrow \dot{m}_{W3} = 900 - 40 = 860 \text{ kg/hr}$$

$$x_{E3} = \frac{40 \text{ kg/hr}}{900 \text{ kg/hr}} = 0.044$$

$$x_{W3} = \frac{860}{900} = 1 - 0.044 = 0.956$$

$$\dot{m}_{\text{bottoms}} =$$

$$x_{E, \text{bottoms}} =$$

$$x_{W, \text{bottoms}} =$$