

CHAPTER 4

MATERIAL BALANCE FOR ACETIC ACID PLANT:

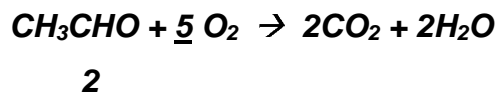
Let the conversion be = x

From literature, selectivity to acetic acid(AA) = 94 %

BASIS : 100 kmol of acetaldehyde

∴ conversion to AA = (100*0.94*x) kmol = 94*x kmol

Here, the side reaction is given by



And rest of the gases, nitrogen, excess oxygen, carbondioxide will release through the vent gases.

The unreacted acetaldehyde = 100*(1-x) kmol

and water added = (100*0.06*x)*2 = 12*x kmol

Also, the reaction mixture contains 94% acetic acid.

Let, 50% of acetaldehyde loss has been recovered in scrubbing tower.

∴ the final reaction mixture contains,

Acetic acid = 94*x

Acetaldehyde = 100*(1-x)*0.5
= 50*(1-x)

Water = 12*x

∴ the wt.% = $(94x*60.05)/(94x*60.05 + 50(1-x)*44 + 12x*18)$
of AA

where F = (94x*60.05 + 50(1-x)*44 + 12x*18)

∴ 0.94 x = (94x*60.05)/(94x*60.05 + 50(1-x)*44 + 12x*18)

∴ x = 0.938

∴ the conversion (x) = 0.938

∴ AA wt% = 94%

$$\therefore \text{water wt\%} = 3.6\%$$

$$\therefore \text{acetaldehyde wt\%} = 2.4\%$$

Ist distillation column:-

Assuming, $x_D = 0.98$

$$x_w = 0.89$$

$$D = \frac{F(x_D - x_F)}{(x_D - x_w)} = \frac{5633.73(0.98 - 0.94)}{(0.98 - 0.89)}$$

$$(0.98 - 0.89)$$

$$W = (F - D) = 1126.74 \text{ kg}$$

IInd Distillation Column:

Assume, $x_{D1} = 0.58$ and $x_{D2} = 0.996$

$$x_w = 0.998$$

$$F = D_1 + D_2 + W$$

$$F x_F = D_1 x_1 + D_2 x_2 + W x_w$$

Assuming, the yield is only 60%.

$$\therefore D_2 = 100 \times 0.6 = 3600 \text{ kg}$$

$$\text{and } F = 4506.98 \text{ kg}$$

$$F = 4506.98 \text{ kg}$$

$$\therefore D_1 + W = 906.88$$

$$\therefore D_1 x_{D1} + W x_w = (4506.98 \times 0.98 - 3600 \times 0.996) = 831.24$$

$$\text{Knowing } x_{D1} \text{ and } x_w, D_1 = 174.52 \text{ kg and } W = 732.46 \text{ kg}$$

Now, for 100 kmol of acetaldehyde feed, product recovery of 99.6% pure AA is 3600 kgs.

\therefore For 150 ton/day production of AA,

Feed of acetaldehyde

$$\text{required is} = (100 \times 44 \times 150 \times 10^3 / 3600)$$

$$= 1,83,333.33 \text{ kgs/day}$$

$$\text{Acetaldehyde in kmol} = 4166.67 \text{ kmols/day}$$

From stoichiometry,



$$\therefore O_2 \text{ required in kmol} = 4166.67/2 = 2083.33 \text{ kmol/day}$$

$$O_2 \text{ required in kg} = 66,666.56 \text{ kg of } O_2/\text{day}$$

Now, supplying 25% excess of O_2 :

$$O_2 \text{ supply in kg} = 66,666.56 * 1.25 = 83,333.2 \text{ kgs } O_2/\text{day}$$

$$O_2 \text{ is diluted by 10\%} = 83,333.2/0.9$$

$$= 92592.44 \text{ kgs diluted } O_2/\text{day}$$

$$N_2 \text{ present in } O_2 = 92592.44 * 0.1 = 9259.24 \text{ kgs } N_2/\text{day}$$

$$\text{Now, } O_2 \text{ oxidised to acetic acid} = 4166.67 * 0.938 * 32/2$$

$$= 62,533.38 \text{ kgs/day}$$

$$\therefore \text{Unreacted } O_2 = (83,333.2 - 62,533.38) = 20,799.82 \text{ kgs/day}$$

$$\therefore \text{Unreacted acetaldehyde} = 1,83,333.33 * (1 - 0.938)$$

$$\therefore = 11,366.64 \text{ kgs/day}$$

$$\therefore \text{Acetaldehyde lost in vapor stream} = 11,366.4 * 0.5$$

$$\therefore = 5683.2 \text{ kgs/day}$$

NOW, Final Exit Stream contains(Basis/day)

$$\text{Oxygen} = 20,799.82 \text{ kgs}$$

$$\text{Nitrogen} = 9,259.24 \text{ kgs}$$

$$\text{Acetaldehyde} = \underline{5,683.32 \text{ kgs}}$$

$$35,742.38 \text{ kgs}$$

$$\text{Wt.\% } CH_3CHO = 5683.32/35742.38 = 15.9$$

Assuming, the concentration of Acetaldehyde in exit stream from scrubber is 0.5%.

\therefore Amount of acetaldehyde

$$\text{recovered} = (20799.82 + 9259.24) * \frac{(0.1590)}{(1-.159)} - \frac{(0.005)}{(1-.005)}$$

$$= 5531.93 \text{ kg}$$