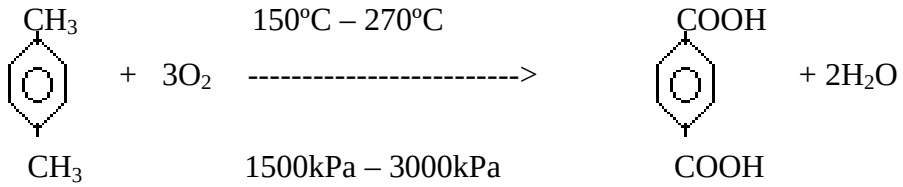
MATERIAL BALANCE

CHEMICAL REACTION:



OVERALL BALANCE:

Basis: 750 x 10^3 Kg of Terephthalic acid

Given:

Purity of Product - 99%

Conversion - 95%

Solvent - 0.05 Kg / Kg of product

O_2 - 5 – 15 % excess from theoretical value

For 1 day basis:

Product:

From data product is 99% pure assume rest 1% is water.

Therefore amount of product (Terephthalic acid) = 742500 Kg = 4472.89 Kmoles

Water associated with it = 7500 Kg = 416.67 Kmoles

Feed:

From the chemical equation 1 Kmole of p-Xylene = 1 Kmole of Product

But given that conversion is 95%

Therefore 1 Kg mole of p- xylene = 0.95 of Terephthalic acid

Therefore amount of p-Xylene reqd. = 4472.89/0.95 = 4708.31Kmoles = 499080.86 Kg

Unconverted Feed = 0.05 x 4708.31 = 235.41 Kmoles =24953.46 Kg

Air:

1 Kmole of p-Xylene = 3 Kmoles of Oxygen

Therefore theoretical amount of Oxygen reqd. = 4708.31 x 3 = 14124.92 Kmoles

An excess of 15 % is used to inhibit the formation of byproducts

Excess amount of oxygen = 14124.92 x 0.15 = 2118.74 Kmoles

Total amount of Oxygen = 16243.66 Kmoles

Nitrogen associated = (79/21) x 16243.66 = 61107.1 Kmoles

Total Air required = 77350.76 Kmoles = 2229.79 x 10^3 Kg

Water:

1 Kmole of PTA = 2 Kmole of H_2O

Amount of water formed = 4472.89 x 2 = 8945.78 Kmoles = 161.02x10^3 Kg

Oxygen in outlet:

Amount of oxygen leaving the system = 5% unreacted + 15% excess

Amount of oxygen leaving = 2824.99 Kmoles = 90.399x10^3 Kg

Solvent Required:

Given that solvent required = 0.05 Kg/Kg of PTA

Amount of Acetic Acid required = 625 Kmoles = 37.5 x 10^3 Kg

Balance across each equipment:

<u>Reactor & G-L separator:</u>

Basis : 1 Day operation

INLET:

Component	Kmoles	Kg x 10^{-3}
p-Xylene	4708.31	499.01
Acetic Acid	625	37.5
Air	77350.76	2229.79

Total : 2766.3 x 10^3 Kg

OUTLET:

Component	Kmoles	Kg x 10^{-3}
p-Xylene	235.41	24.95
Acetic Acid	625	37.5
Water Formed	8945.78	161.02
Air	63932.09	1800.39
Terephthalic acid	4472.89	742.5

Total: 2766.3 x 10^3 Kg

Surge Tank:

INLET:

Component	Kmoles	Kg x 10^{-3}
p-Xylene	235.41	24.95
Acetic Acid	625	37.5
Water Formed	8945.78	161.02
Air	63932.09	1800.39
Terephthalic acid	4472.89	742.5

Total: 2766.3 x 10^{3} Kg

OUTLET:

Component	Kmoles	Kg x 10^{-3}
p-Xylene	235.41	24.95
Acetic Acid	625	37.5
Water Formed	8945.78	161.02
Air	63932.09	1800.39
Terephthalic acid	4472.89	742.5

Total: 2766.3 x 10^{3} Kg

Centrifuge:

INLET:

Component	Kmoles	Kg x 10^{-3}
p-Xylene	235.41	24.95
Acetic Acid	625	37.5
Water Formed	8945.78	161.02
Air	63932.09	1800.39
Terephthalic acid	4472.89	742.5

Total: 2766.3 x 10^{3} Kg

In the centrifuge two streams separate out

i. Stream to the Rotary Drier (solid + moisture)

ii. Stream to the Residue Still

To Estimate the amount of water entering the Drier:

Assume the drier is capable of removing 60% moisture entering.

We have outlet from the drier as

Terephthalic acid solid = 4472.89 Kmoles.

Water associated with it = 416.67 Kmoles.

Let y be the amount of water in inlet of the drier.

$y - 0.6\ y = 416.67$ Kmoles.

Therefore the inlet to the drier $y = 416.67/0.4 = 1041.68$ Kmoles $= 18.75 \times 10^3$ Kgs.

Water removed in the drier (60%) $= 11.25 \times 10^3$ Kgs.

Water to the residue still $= 142.3 \times 10^3$ Kgs.

Drier:

INTLET:

Acetic acid enters the drier in a negligible amount and hence can be neglected

Component	Kmoles	Kg x 10^{-3}
Water	1041.67	18.75
Terephthalic acid	4472.89	742.5

Total: 761.25×10^3 Kg

OUTLET:

Component	Kmoles	Kg x 10^{-3}
Water	416.67	7.5
Terephthalic acid	4472.89	742.5

Water Lost (evaporated) : 11.25×10^3 Kgs

Total : 761.25×10^3 Kgs

Residue Still:

INLET:

Component	Kmoles	Kg x 10^{-3}
p-Xylene	235.41	24.95
Acetic Acid	625	37.5
Water Formed	7905.56	142.3

Total : 204.75×10^3 Kgs

OUTLET:

p-Xylene is a heavy key and hence in trace amounts in the distillate.

From the date it is given that about 80 – 95 % of acetic acid is recovered hence assume that 20%(mole) goes in the residue stream and about 10%(mole) of water entering goes in the residue.

Component	Distillate (Kgs) x 10^{-3}	Residue (Kg) x 10^{-3}
p-Xylene	-	24.95
Acetic Acid	35.68	1.82
Water Formed	128	14.3

Total : 204.75 x 10^3 Kgs

Condenser:

Considering the reflux for the still reflux is taken as 0.6

The vapor entering the condenser = 1.6 x 163.68 x 10^3 Kgs = 261.89 x 10^3 Kgs.

Reflux to the Still = 98.21 x 10^3 Kgs.

Feed to the dehydration tower = 163.68 x 10^3 Kgs.

Dehydration Tower:

INLET:

Acetic Acid : 24.738 Kmole/Hr

Water : 296.25 Kmoles/Hr

Feed : 321 Kmoles/Hr

X_F = 0.93

$F X_F = D X_D + W X_W$

W (Residue) = 22.134 Kmoles/Hr

D (Distillate) = 298.866 Kmoles/Hr

X_D = 0.998, X_W = 0.012

Assume reflux ratio is 0.6

Condenser:

Feed to the condenser = 1.6 x 5.379 x 10^3 Kgs/Hr = 8.61 x 10^3 Kgs/Hr

Reflux to the dehydration tower = 3.23 x 10^3 Kgs/Hr

Distillate (water) = 5.379 x 10^3 Kg/Hr