4. MATERIAL BALANCE

Material Balance:

Basis: Per hour of operation

Amount of cumene to be obtained = 1 M ton of cumene per annum.

$= 10^6/330$ tons per day of cumene.

$= 10^6/(330 \times 24)$ tons of cumene per hr.

$= 126.26 \times 10^3$ kg of cumene per hr.

$= (126.26 \times 10^3)/120.19$ kmoles of cumene per hr.

= 1050.50 Kgmole/hr

Assuming 97% conversion and 2% loss.

∴ Cumene required = 1050.50/ .98 =1071.94 Kgmoles/hr

= 128836.32 Kg/hr

Hence 128836.32 kg of cumene is required to be produced per hr.

Propylene required =1071.94/.97 = 1105.09 Kgmole

= 1105.09 x 42 Kg/hr of propylene

= 46413.78 Kg/hr of propylene

Assuming benzene required is 25% extra

= 1105.09 x 1.25 Kmoles of benzene

= 1381.3625 Kgmole/hr

= 107746.27 Kg/hr

Propane acts as an inert in the whole process . It is used for quenching purpose in the reactor. It does not take part in the chemical reaction . Also

It is inevitably associated with the propylene as an impurity as their molecular weight is very close.

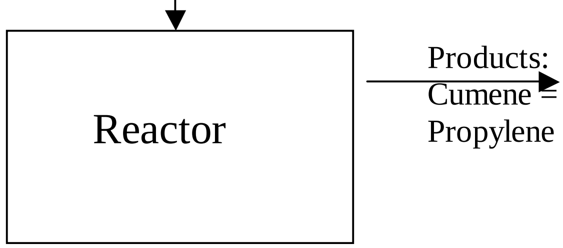
We assume propylene to propane ratio as 3:1.

Being an inert we are neglecting propane balance in the material balance to avoid complexity.

1.) Material balance around reactor :

Propylene = 46413.78 Kg/hr

Benzene = 107746.27 Kg/hr



Products:

Cumene = 128836.32 Kg/hr

Propylene = 1105.09-1071.94

=33.15 Kmoles/hr is reacted to give DIPB

Benzene required to give DIPB

= 33.15/2 kmoles/hr

= 16.575 kmoles/hr

DIPB produced= 16.575 x 162 = 2685.15 Kg/hr

Benzene in product = 1381.3625 – 1071.94 -16.575

= 292.85 kmoles/hr

= 22820.85 kg/hr

Input = 46413.78 + 107746.27 = 154160.05 Kg/hr

Output = 128836.32 + 2685.15 + 22820.85= 154342 Kg/hr

Input = output

2) Distillation column 1: (Depropanasing column)

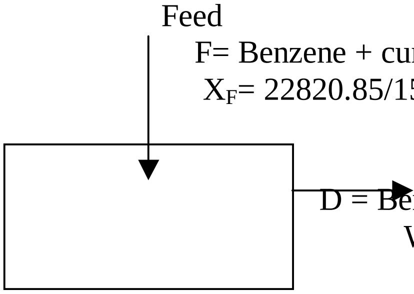
Assuming almost all the propane is removed in depropanising column and sent to reactor for quenching.Hence material balance for depropanasing column is not considered.

3.) Distilation colume 1: (Benzene column)

Feed

F= Benzene + cumene + DIPB = 154160 Kg/hr

X_F= 22820.85/154160 = 0.1480



D = Benzene = 15969.41Kg/hr

W= Cumene + DIPB = 138190 Kg/hr

F = D + W

154160 = D +W

$F X_F = DX_D + WX_w$

Taking X_F = 0.9999

X_D = 0.05

154160 x 0.1480 = D x 0.9999 +W x 0.05

3023.5 = .9999 D + (20374 – D) x 0.05

D = 15969.41 Kg/hr

= Benzene

W = 154160 – 15969.41

= 138190.5 Kg/hr

= cumene + DIPB

Input = 154160 kg/hr

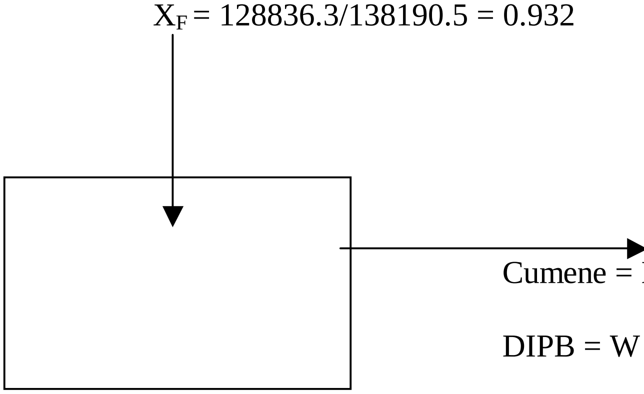
Output = 15969.41 + 138190.5
= 154160 kg/hr
Input = Output

Assuming all the Benzene present in benzene column is recycled to the feed . Hence considering negligible amount of benzene to be part of residue.This will avoid the complexity of multicomponent distillation in
Cumene column.

Therefore amount of benzene recycled = 15969.5 Kg/hr.
Therefore feed actually given to the system = 154160 + 15969.5
= 170129.5 Kg/hr

4.).Distilation column 3: (Cumene column)

F = Cumene + DIPB = 138190.5 Kg/hr
X_F = 128836.3/138190.5 = 0.932



Cumene = D = 17065.2Kg/hr

DIPB = W = 371.79Kg/hr = 2%

F = D +W
138190.6 = D +W
$FX_F = DX_D + WX_W$
Taking X_D = 0.995
X_W = 0.01
138190.5 x 0.932 = D x 0 .995 + W x 0.01
128793.54 = 0.995D + (138190.5 – D) 0.01

D = 129051 kg/hr
W = 138190.5 – 129051
= 9139.5 Kg/hr

Input = 138190.5 Kg/hr

Output = 129051 + 9139.5

= 138190.5 Kg/hr.

Input = output