

MATERIAL BALANCE

Feed contains toluene, naphthalene, dimethylnaphthalene, hexadecene. The naphthalene produced is usually better than 99 % pure and low in sulfur content. 95% feed made up of aromatic.

BASIS: 100 Kg feed.

So feed composition

20 –30% toluene

10 – 15% naphthalene

50 – 60% methylnaphthalene

<u>COMPONENT</u>	<u>WEIGHT PERCENT</u>
Toluene	20 –30%
Naphthalene	10 – 15%
Methylnaphthalene	50 – 60%
Hexadecene	5%

Let the feed composition

<u>COMPONENT</u>	<u>WEIGHT PERCENT</u>	<u>MOLECULAR WT.</u>
Toluene	25	92
Naphthalene	15	128
Methylnaphthalene	55	156
Hexadecene	5	226

Number of Moles =(Weight \ Molecular wt)

Mole of toluene = 0.2717

Mole of naphthalene =0.1171

Mole of methylnaphthalene =0.3525

Mole of hexadecene =0.02212

Total mole of feed =0.76342

Mole fraction = (mole\ total mole)

<u>COMPONENT</u>	<u>MOLE PERCENT</u>
Toluene	35.58
Naphthalene	15.33
Methylnaphthalene	46.17
Hexadecene	2.877

$$\begin{aligned} \text{Avg. molecular wt of feed} &= (92 \times 0.355 + 128 \times 0.1534 + 156 \times 0.4617 + 226 \times 0.0289) \\ &= 130.951 \text{ kg} \backslash \text{ kmole} \end{aligned}$$

Production capacity = 450,000 Tpy

Assume in year plant working 330 day and in a day plant working 20 hours.

$$\begin{aligned} \text{Plant capacity} &= (450,000,000) \backslash (330 \times 20) \\ &= 68181.82 \text{ kg} \backslash \text{ hr} \end{aligned}$$

Let composition of product :

<u>COMPONENT</u>	<u>WEIGHT PERCENT</u>	<u>MOLE FRACTION</u>
Toluene	0.2	2.78×10^{-3}
Naphthalene	99	0.9911
Methylnaphthalene	0.8	6.572×10^{-3}
Hexadecene	0	0

Moles of naphthalene in product

$$\begin{aligned} &(6181.82 \times 0.99) \backslash 128 \\ &= 527.34 \text{ Kmole} \backslash \text{hr} \end{aligned}$$

Moles of dimethylnaphthalene in product

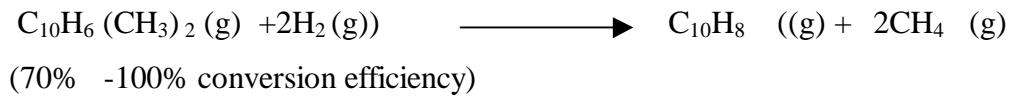
$$\begin{aligned} &= (68181.82 \times 0.008) \backslash 156 \\ &= 3.49 \text{ Kmole} \backslash \text{hr} \end{aligned}$$

Moles of toluene in product

$$\begin{aligned} &(6181.82 \times 0.002) \backslash 226 \\ &= 1.4822 \text{ Kmole} \backslash \text{hr} \end{aligned}$$

Total moles of product = 532.3122 Kmole/hr

Dimethylation reaction



Naphthalene in 1 mole feed

$$\begin{aligned} &= (\text{Moles present in feed} + \text{moles by conversion}) \\ &= (0.15338 + 0.92 \times 0.46517) \\ &= 0.5782 \text{ mole of naphthalene} \end{aligned}$$

When 0.5782 mole naphthalene then product = 527.34 Kmole/hr

One mole naphthalene then product = $(527.34) / (0.5782)$

$$F_D = 911.936 \text{ Kmole/hr}$$

Toluene in feed = 324.54 Kmole/hr

TOLUENE TOWER:

Let composition in stream T

<u>COMPONENT</u>	<u>MOLE PERCENT</u>
Toluene	99.00
Naphthalene	1.00

Over all toluene balance

$T = (\text{Kmole/hr of toluene in feed} - \text{that in product})$

$$= (324.54 - 1.4822)$$

$$= 326.331 \text{ Kmole/hr}$$

Naphthalene in stream T = 0.01×326.33

$$= 3.263 \text{ Kmole/hr}$$

Hexadecane in feed = 911.934×0.02893

$$= 26.420 \text{ Kmole/hr}$$

Naphthalene produced by reactor is:

$$= 527.34 - (911.934 \times 0.1534)$$

$$= 390.71 \text{ Kmole/hr}$$

Mole fraction is

$$= (390.71 / 911.396)$$

$$= 0.4284$$

Corrected overall conversion = 92.796%

Dimethylnaphthalene in stream H:

$$= 421.040 - 3.49 - 390.71$$

$$= 27.38 \text{ Kmole/hr}$$

Total moles in H stream:

Moles of ($C_{16}H_{34}$) + (mole of Dimethylnaphthalene)

$$= 26.420 + 27.38$$

$$= 53.8 \text{ Kmole/hr}$$

Composition of H stream

COMPONENT	MOLEPERCENT
Dimethylnaphthalene	50.89
$C_{16}H_{34}$	49.11

NAPHTHALENE TOWER:

Here we assume the composition of stream F

	Mole %
Toluene (x_{1F})	0.0012
Naphthalene(x_{2F})	0.60
Dimethylnaphthalene(x_{3F})	0.3988
Hexadecane (x_{4F})	0

Over all toluene balance

$$0.0012F = 1.4822$$

$$F = 1235.166$$

Over all balance

$$F = P + D$$

$$D = 1235.166 - 532.312$$

$$= 703.046 \text{ Kmole/hr}$$

Overall Naphthalene balance

$$0.6(1235.166) = 527.43 + X_{2D}D$$

$$X_{2D} = 0.3040$$

$$X_{1D} = X_{4D} = 0$$

$$X_{2D} + X_{3D} = 1$$

$$X_{3D} = 0.6959$$

<u>MATERIAL</u>	<u>MOLE PERCENT</u>
Toluene	0
Naphthalene	0.3040
Dimethylnaphthalene	0.6959
Hexadecane	0

TOWER (II) & (III):

Let mole fraction of naphthalene in stream $F_2 = 0.69$

Let mole fraction of naphthalene in stream $F_3 = 0.1$

Since the reaction does not change the total mole of liquid and gases ($H_2 + CH_4$)

Which are immiscible with liquid which are removed in the separator .

Feed in ii tower $F_2 = F_D + D + R - T$

$$= R + 1288.651 \text{ Kmole/hr}$$

Naphthalene balance around tower ii ;

$$(R + 1288.651) \times 0.69 = (1235.166) \times 0.89 + R + 53.8$$

$$R = 365.271 \text{ Kmole/hr}$$

$$F_3 = R + H$$

$$= 419.071 \text{ Kmole/hr}$$

$$F_2 = 1653.92 \text{ Kmole/hr}$$

Let Toluene mole fraction in stream $F_2 = 0.0008$

Let Toluene mole fraction in stream $F_3 = 0$

Let Dimethylnaphthalene mole fraction in stream $F_2 = 0.275$

Dimethylnaphthalene balance around tower ii :

$$F_2(0.275) = F_3 X_{3F3} + F(0.1088)$$

$$X_{3F3} = 0.7646$$

TOWER I :

$$F_1 = F_2 + T$$

$$= 1980.251 \text{ Kmole/hr}$$

Toluene balance around tower i

$$1980.251 X_1 = 0.99 \times 326.331 + 0.0008 \times 1653.92$$

$$X_1 = 0.1638$$

Naphthalene balance around tower i

$$1980.251 X_2 = 0.1 \times 326.331 + 0.69 \times 1653.93$$

$$X_2 = 0.5927$$

Dimethylnaphthalene balance around tower I

$$1980.251 X_3 = 1653.93 \times 0.275$$

$$X_3 = 0.2296$$

Hexadecane balance

$$X_4 = 1 - (X_1 + X_2 + X_3)$$

$$X_4 = 0.0139$$

BALANCE AROUND JUNCTION J₁ :

$$F_{DD} = F_D + R$$

$$= 1276.670 \text{ Kmole/hr}$$

Toluene balance

$$F_D \times 0.35589 = F_{DD} \times X_1$$

$$911.33 \times 0.35589 = 1276.607$$

$$X_1 = 0.254$$

Naphthalene balance

$$1276.607 X_2 = 911.336 \times 0.1534 + 365.271 \times 0.1167$$

$$X_2 = 0.1423$$

Dimethylnaphthalene balance

$$1276.607 X_3 = 911.336 \times 0.4617 + 365.271 \times 0.8022$$

$$X_3 = 0.5591$$

Hexadecane balance

$$X_4 = 1 - (X_1 + X_2 + X_3)$$

$$X_4 = 0.0445$$

H₂ : Naphthalene = 5 : 1

Kmole of Dimethylnaphthalene in F_{DD} stream

$$= 1276.607 \times 0.5591$$

$$= 713.750 \text{ Kmole/hr}$$

So that H₂ = 5 x 713.750

$$= 3568.75 \text{ Kmole/hr}$$

$$= 7137.5097 \text{ Kg}$$

Here H₂ is goes into the reactor

In put in reactor = F_{DD} + H₂

$$= 1276.60 + 3568.75$$

$$= 4845.35 \text{ Kmole/hr}$$

BALANCE AROUND JUNCTION J₂:

Over all balance

Toluene balance

$$LX_1 = 1980.245 \times 0.1688$$

$$X_1 = 0.2539$$

Naphthalene balance

$$1277.205 \times X_2 = 1980.251 \times 0.5927 - 703.046 \times 0.8137$$

$$X_2 = 0.471$$

Dimethylnaphthalene balance

$$1980.251 \times X_3 = 1277.205 \times X_3 + 703.046 \times 0.1862$$

$$X_3 = 0.2534$$

Hexadecane balance

$$X_4 = 1 - (X_1 + X_2 + X_3)$$

$$X_4 = 0.02155$$

REACTOR BALANCE

Dimethylnaphthalene input to reactor = 4845.38 Kmole/hr

Dimethylnaphthalene input to reactor = 1276.607 x 0.5591

$$= 713.750 \text{ Kmole/hr}$$

$$\begin{aligned} \text{Dimethylnaphthalene output from reactor} &= 1277.205 \times 0.2534 \\ &= 323.6437 \text{ Kmole/hr} \end{aligned}$$

$$\begin{aligned} \text{Dimethylnaphthalene converted} &= 713.75 - 323.6437 \\ &= 390.106 \text{ Kmole/hr} \end{aligned}$$

$$\begin{aligned} \text{Per pass conversion in reactor} &= (390.106 / 713.75) \times 100 \\ &= 54.65\% \end{aligned}$$

Mathen gas produced in the reactor

= Moles of Dimethylnaphthalene reacted

$$= 390.106 \text{ Kmole/hr}$$

$$\begin{aligned} \text{H}_2 \text{ un reacted} &= 3568.75 - 390.106 \\ &= 3178.64 \text{ Kmole/hr} \end{aligned}$$

Balance around separator

Over all balance

$$C = L + G$$

$$G = 3568.75 \text{ Kmole/hr}$$

H₂ balance

$$\text{H}_2 \text{ in feed} = 3568.75$$

$$\text{H}_2 \text{ un reacted} = 3178.644$$

$$\% \text{ Of H}_2 \text{ in stream G} = 3178.64 / 3568.75 = 0.890$$

$$\text{CH}_4 \text{ in stream G} = 11\%$$