MATERIAL BALANCE

Let R is the recycle feed from column 4 per kg of feed.

The reaction is taking place in the ISOMAR reactor, which converts Ethyl Benzene and meta-xylene to ortho-xylene and para-xylene.

Assumptions made:

Let the conversion be 70% and the reaction product gives product yield of ortho-xylene and para-xylene in 1:1.33 ratios.

Selectivity of Mesitylene =30%

Selectivity of C_7 conversion=10%

From the known data the composition in the feed stream is as follows,

Ethyl Benzene – 17.3%

Para-xylene – 17.6%

Meta-xylene – 43.3%

Ortho-xylene – 21.8%

Let

Basis: - 100 kg / hr of feed.

Recycle stream=100R kg

Therefore overall material balance around column 4 gives

100+K = 100R + W

Let us assume the top product composition is

Ethyl Benzene – 25%

Para-xylene – 30%

Meta-xylene – 30%

Ortho-xylene – 15%

Therefore

Amount of Ethyl Benzene in recycle = 100R*0.25

Amount of meta-xylene in recycle = 100R*0.3

Amount of para-xylene in recycle = 100R*0.3

Amount of ortho-xylene in recycle = 100R*0.15

In parex separator, para-xylene is been extracted at 95% efficiency.

Therefore the amount of unextracted para-xylene in the recycle stream (R_1) from parex separator = 100R*0.30(1-0.95)

=100R*0.30*0.05

=1.5R

Assumption made:

There be no loss of meta-xylene, ortho-xylene, and Ethyl Benzene since all isomers, weight%=mol%.

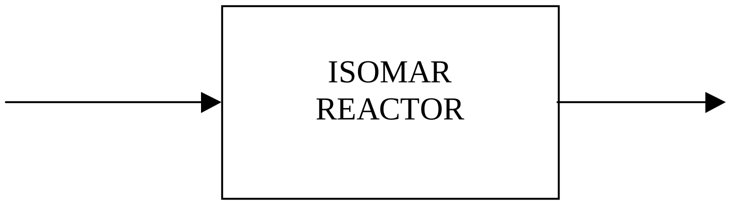
Therefore, the composition of R_1 gives as,

Ethyl Benzene = 25R

Meta-xylene = 30R

Para-xylene = 1.5R

Ortho-xylene = 15R



Therefore unconverted Ethyl Benzene = (1-0.70)*25R

= 7.5R

Unconverted Ethyl Benzene = (1-0.70)*30R

= 9R

Therefore mass of para-xylene leaving the reactor in stream R_2=

=1.5R+ (25R+30R)*0.7*0.6*1.33 / 1+1.33

=14.68R.

Therefore mass of ortho-xylene leaving the reactor in stream R_2=

=1.5R+ (25R+30R)*0.7*0.6*1 / 1+1.33

=24.91R.

Therefore mass of C_7 compound leaving the reactor in stream R_2=

= (25R+30R) / 106*0.7*0.1*92

=3.34R.

Therefore mass of C_9 compounds leaving the reactor in stream R2=

= (25R+30R) / 106*0.7*0.3*120

=13.07R.

Assumption made:

Let all the C_7 compound been recovered in the column3

Therefore in stream k,

Ethyl Benzene – 7.5R

Para-xylene – 14.68R

Meta-xylene – 9R

Ortho-xylene – 24.91R

C_9 – 13.07R

Weight of k stream = 69016R.

Now,

Composition of the stream F' entering

Ethyl Benzene = 7.5R+100*0.173 / (69016R+100)

= 705R+17.3 / (69.16R+100)

Assumption of column 4:

x_d = 0.25

x_w = 0.001

Now,

$Fx_F = Dx_D + Wx_W$

$F = D + W$

Therefore,

$Fx_F = Dx_D + (F-D)x_W$

$F (x_F - x_W) = D (x_D – x_W)$

$D = F (x_F - x_W) / (x_D – x_W)$

$= (69.16R+100)*1 / (0.25-0.001)*[(7.5R+17.3) / (69.16R+100) - .001]$

Now,

$D=100R$

$100R = (1 / 0.249)*(7.5R + 17.3 - 0.06916R – 0.1)$

$24.9R=7.4308R + 17.2$

$R= 17.2 / (24.9 – 7.4308)$

$R = 0.984$

Therefore the mass balance gives,

$F = D + W$

$Fx_F = Dx_D + Wx_W$

$Fx_F = (F – W)x_D + Wx_W$

$W= F (x_F – x_D) / (x_W – x_D)$

$= F (x_D – x_F) / (x_D – x_W)$

Where, $F = 69.16R+100 = 168.05$

$W = 168*(0.25 – 0.1468) / (0.25 – 0.001)$

$= 69.649$ kg.

Now,

<u>For mesitylene balance</u>: -

Consider the specification for the last column.

$x_{D'} = 99\%$

$x_{W'} = .1\%$

On the basis of ortho-xylene in the feed stream,

$W = (24.91*0.984 + 100*0.218) - (100*0.984*0.15) = 31.55$ kg.

$W = D' + W'$

$Wx_W = D'x_D' + W'x_W'$

$Wx_W = (W - D')\, x_W' + D'\, x_D'$

$W\,(x_W - x_W') = D'\,(x_D' - x_W')$

$D' = W\,(x_W - x_W') / (x_D' - x_W')$

$= 69.649*(0.453 – 0.001) / (0.99 – 0.001)$

$= 31.83$ KG.

Making the material balance to obtain 35000tons / yr of ortho-xylene, we get,

Let

Basis: - 13883.7 kg of feed.

Recycle stream = 13883.7R kg

Therefore overall material balance around column 4 gives

13883.7+K = 13883.73R + W

Let us **assume** the top product composition is

Ethyl Benzene – 25%

Para-xylene – 30%

Meta-xylene – 30%

Ortho-xylene – 15%

Therefore

Amount of Ethyl Benzene in recycle = 13883.73R*0.25

Amount of meta-xylene in recycle = 13883.73R*0.3

Amount of para-xylene in recycle = 13883.73R*0.3

Amount of ortho-xylene in recycle = 13883.73R*0.15

In parex separator, para-xylene is been extracted at 95% efficiency.

Therefore the amount of unextracted para-xylene in the recycle stream (R_1) from parex separator = 13883.73R*0.30(1-0.95)

=13883.73R*0.30*0.05

=208.256R

Assumption made

There be no loss of meta-xylene, ortho-xylene, and Ethyl Benzene since all isomers, weight%=mol%.

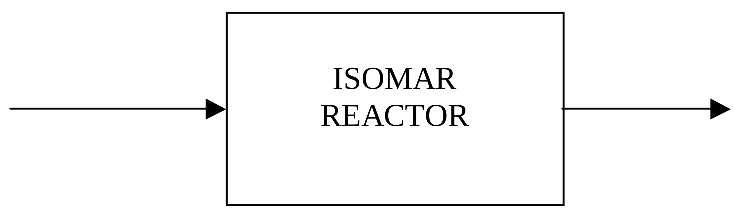
Therefore, the composition of R_1 gives as,

Ethyl Benzene = 3470.93R

Meta-xylene = 4165.119R

Para-xylene = 208.256R

Ortho-xylene = 2082.559R



Therefore unconverted Ethyl Benzene = (1-0.70)*3470.93R

= 1041.279R

Unconverted Ethyl Benzene = (1-0.70)*4165.1192R

= 1249.5357R

Therefore mass of para-xylene leaving the reactor in stream R_2=

=208.256R+ (3470.93R+4165.1192R)*0.7*0.6*1.33 / 1+1.33

=2038.94R.

Therefore mass of ortho-xylene leaving the reactor in stream R_2=

=2082.559R+ (3470.93R+4165.119R)*0.7*0.6*1 / 1+1.33

=3459.014R.

Therefore mass of C_7 compound leaving the reactor in stream R_2=

= (3470.93R+4165.119R) / 106*0.7*0.1*92

=463.92R.

Therefore mass of C_9 compounds leaving the reactor in stream R_2=

= (3470.93R+4165.119R) / 106*0.7*0.3*120

=1815.36R.

Assumption made:

Let all the C_7 compound been recovered in the column3

Therefore in stream k,

Ethyl Benzene – 1041.279R

Para-xylene – 2038.94R

Meta-xylene – 1249.5357R

Ortho-xylene – 3459.014R

C9 – 1815.36R

Weight of k stream = 9604.1287R.

Now,

Composition of the stream F' entering

Ethyl Benzene=1041.279R+13883.73*0.173 / (9604.1287R+13883.73)

= 1041.279R+2401.88 / (9604.1287R+13883.73)

Assumption of column 4:

x_d = 0.25

x_w = 0.001

Now,

$Fx_F = Dx_D + Wx_W$

$F = D + W$

Therefore,

$Fx_F = Dx_D + (F-D)x_W$

$F (x_F - x_W) = D (x_D – x_W)$

$D = F (x_F - x_W) / (x_D – x_W)$

$=(9604.1287R+13883.73)*1/(0.25-0.001)*[(1041.279R+2401.88)/(9604.1287R+13883.73) - 0.001]$

Now,

D=13883.73R

13883.73R = (1/0.249)*(1041.279R +2401.88 -9.604R –13.88)

3457.048R=1031.675R +2388

R= 2388 / (3457.08– 1031.675)

R = 0.984

Therefore the mass balance gives,

F = D + W

$Fx_F = Dx_D + Wx_W$

$Fx_F = (F – W)x_D + Wx_W$

$W= F (x_F – x_D) / (x_W – x_D)$

$= F (x_D – x_F) / (x_D – x_W)$

Where, F = 9604.1287R+13883.73 = 23339.866

W =9673.39 kg.

Now,

For mesitylene balance:

Consider the specification for the last column based on ortho-xylene

$x_{D'}$ = 99%

$x_{W'}$ = .01%

Amount of ortho-xylene in the feed stream,

W = (3459.014*0.984 + 13883.73*0.218) - (13883.73*0.984*0.15)

= 4381.084 kg.

W = D’ + W’

$Wx_W = D'x_D' + W'x_W'$

$Wx_W = (W- D')\, x_W' + D'\, x_D'$

$W\ (x_W - x_W') = D'\ (x_D' - x_W')$

$D' = W\ (x_W - x_W') / (x_D' - x_W')$

$= 4421$ kg.

$W' = 5252.38$ kg.

Therefore Fresh feed entering the plant = 13883.73 kg / hr

Assuming 10% spillage and handling losses,

Feed required = 1.1*F = 1.1 * 13883.73 = <u>15272.103</u> kg / hr