Chapter II
• Steam required for process:-

Let,

Crushing rate = 100 TCH ; Latent heat of Exhaust = 535 K.Cal/kg  
M.Jc. = Cl.Jc. % cane = 100  
R.Jc. Heating = 30 to 70°C ;  2nd = 543  
SJ1 Heating = 65 to 90°C ;  3rd = 550  
SJ2 Heating = 90 to 103°C ;  4th = 566  
Cl.Jc. Heating = 95 to 105°C;  
Cl.Jc. Brix % = 15°  
Syrup Brix % = 60°

• Case I ) Steam required without vapour bleeding:-

1) Steam requirement for Raw juice heating from 30 to 70°C.

\[ Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (70 - 30)}{535} = 6.728 \text{ Ts/hr.} \]

2) Steam requirement for Sulphur juice heating from 65 to 103°C.

\[ Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (103 - 65)}{535} = 6.393 \text{ Ts/hr.} \]

3) Steam requirement for clear juice heating from 95 to 103°C.

\[ Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (103 - 95)}{535} = 1.682 \text{ Ts/hr.} \]
4) Evaporation in evaporator

\[
\frac{60 - 15}{60} \times 100 = 75.00 \%
\]

Therefore steam required for each body = \[\frac{75}{4} = 18.75\]

Steam requirement for pan varies from 20 to 30% on cane. Let us assume 25% on cane.

Thus, total steam requirement---

For Raw juice = 6.723
Sul. juice = 6.393
Cl. juice = 1.682
Evaporator = 18.750
Pan = 25.000
Miscellaneous = 5.000

Total = 63.55 Ts/hr ≈ 64 Ts/hr.

- Case II) Steam required with vapour bleeding from 1st body of quad to R.Juice. & S.J1 heater:

1) Steam requirement for Raw juice heating from 30 to 70°C.

\[
\frac{Q_j \times C_j \times \Delta T}{Latent \ heat} = \frac{100 \times 0.9 \times (70 - 30)}{538.9} = 6.68 \text{ Ts/hr.}
\]

2) Steam requirement for Sul. Jc. 1st heating from 65 to 90°C.

\[
\frac{Q_j \times C_j \times \Delta T}{Latent \ heat} = \frac{100 \times 0.9 \times (90 - 65)}{538.9} = 4.175 \text{ Ts/hr.}
\]
Latent heat 538.9

Total vapour from 1st of quad for R.Jc. & S.Jc frist heating is 6.68 + 4.175 = 10.855 Ts/Hr.

3) Steam requirement for Sul. Jc. 2nd heating from 90 to 103°C.

\[
\begin{align*}
Q_j \times C_j \times \Delta T &= \frac{100 \times 0.9 \times (103 - 90)}{L \text{atent heat}} \\
&= \frac{100 \times 0.9 \times 13}{535} \\
&= \frac{1350}{535} \\
&= 2.52 \text{ Ts/hr.}
\end{align*}
\]

4) Steam requirement for clear juice heating from 95 to 103°C.

\[
\begin{align*}
Q_j \times C_j \times \Delta T &= \frac{100 \times 0.9 \times (105 - 95)}{535} \\
&= \frac{900}{535} \\
&= 1.682 \text{ Ts/hr.}
\end{align*}
\]

5) Evaporation in evaporator

\[
\begin{align*}
&\frac{60 - 15}{60} \times 100 = 75.00 \% \\
4^{th} \text{ body} &= X \\
3^{rd} \text{ body} &= X \\
2^{nd} \text{ body} &= X \\
1^{st} \text{ body} &= X + 10.855 \\
\text{Total evaporation} &= 4X + 10.855 \\
4X + 10.855 &= 75 \\
X &= 16.036
\end{align*}
\]

Therefore, Exhaust required for quad =16.036 + 10.855 =26.891 Ts/hr.

Steam requirement for pan varies from 20 to 30 % on cane. Let us assume 25 % on cane.

Thus, total steam requirement---

For Sul. juice 2nd heating = 2.187
Cl. juice = 1.682
Evaporator =26.891
Pan = 25.000
Miscellaneous = 5.000

Total = 60.76 % on cane
Case III ) Steam required with vapour bleeding from 2nd body of quad to R.Juice. & From 1st body of quad. To S.J heater:-

1) Steam requirement for Raw juice heating from 30 to 70°C.

\[
Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (70 - 30)}{543} = 6.63 \text{ Ts/hr.}
\]

2) Steam requirement for Sul. Jc. 1st heating from 65 to 90°C.

\[
Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (90 - 65)}{538.9} = 4.175 \text{ Ts/hr.}
\]

Total vapour from 1st of quad for R.Jc. & S.Jc frist heating is 6.68 + 4.175 = 10.855 Ts/Hr.

3) Steam requirement for Sul. Jc. 2nd heating from 90 to 103°C.

\[
Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (103 - 90)}{535} = 2.187 \text{ Ts/hr.}
\]

4) Steam requirement for clear juice heating from 95 to 103°C.

\[
Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (105 - 95)}{535} = 1.682 \text{ Ts/hr.}
\]
5) Evaporation in evaporator

\[
\frac{60 - 15}{60} \times 100 = 75.00\% \\
\]

\[
\begin{align*}
\text{in 4th body} &= X \\
\text{3rd body} &= X \\
\text{2nd body} &= X + 6.63 \\
\text{1st body} &= X + 6.63 + 4.175
\end{align*}
\]

Total evaporation = \(4X + 17.435\)

\[
4X + 17.435 = 75
\]

\[
X = 14.391
\]

Therefore, Exhaust required for quad = 14.391 + 6.63 + 4.175 = 25.196 Ts/hr.

Steam requirement for pan varies from 20 to 30 % on cane. Let us assume 25 % on cane.

Thus, total steam requirement---

For Sul. juice 2nd heating = 2.187
Cl. juice = 1.682
Evaporator =25.196
Pan = 25.000
Miscellaneous = 5.000

\[
\begin{align*}
\text{Total} &= 59.064\% \text{ on cane}
\end{align*}
\]
Case IV: Steam required with vapour bleeding from 1st body of quad to S.J, heater, 2nd body of quad to R.Jc, & 3rd body of quad. To R.Juice, Heater:

1) Steam requirement for Raw juice heating from 30 to 50°C.

\[
Q_J \times C_J \times \Delta T = \frac{100 \times 0.9 \times (50 - 30)}{550} = 3.272 \text{ Ts/hr.}
\]

2) Steam requirement for Raw juice heating from 50 to 70°C.

\[
Q_J \times C_J \times \Delta T = \frac{100 \times 0.9 \times (70 - 50)}{543} = 3.315 \text{ Ts/hr.}
\]

3) Steam requirement for Sul. Jc. 1st heating from 65 to 90°C.

\[
Q_J \times C_J \times \Delta T = \frac{100 \times 0.9 \times (90 - 65)}{538.9} = 4.175 \text{ Ts/hr.}
\]

4) Steam requirement for Sul. Jc. 2nd heating from 90 to 103°C.

\[
Q_J \times C_J \times \Delta T = \frac{100 \times 0.9 \times (103 - 90)}{535} = 2.187 \text{ Ts/hr.}
\]

5) Steam requirement for clear juice heating from 95 to 103°C.

\[
Q_J \times C_J \times \Delta T = \frac{100 \times 0.9 \times (105 - 95)}{535} = 1.682 \text{ Ts/hr.}
\]
6) Evaporation in evaporator

\[
\frac{60 - 15}{60} \times 100 = 75.00 \%
\]

\[
\begin{align*}
4^{th} \text{ body} & = X \\
3^{rd} \text{ body} & = X + 3.272 \\
2^{nd} \text{ body} & = X + 3.272 + 3.315 \\
1^{st} \text{ body} & = X + 3.272 + 3.315 + 4.175 \\
\end{align*}
\]

Total evaporation = \(4X + 20.621\)

\[
4X + 20.621 = 75
\]

\[
X = 13.594
\]

Therefore, Exhaust required for quad =

\[
= 13.594 + 3.272 + 3.315 + 4.175 = 24.356 \text{ Ts/hr.}
\]

Steam requirement for pan varies from 20 to 30 % on cane. Let us assume 25 % on cane.

Thus, total steam requirement---

\[
\begin{align*}
\text{For Sul. juice } 2^{rd} \text{ heating} & = 2.187 \\
\text{Cl. juice} & = 1.682 \\
\text{Evaporator} & = 24.356 \\
\text{Pan} & = 25.000 \\
\text{Miscellaneous} & = 5.000 \\
\end{align*}
\]

\[
\text{Total} = 58.225 \% \text{ on cane}
\]
• Case V ) Steam required with vapour bleeding from 1st body of quad to S.J heater, 3rd body of quad to R.Juice. Heater :-

1) Steam requirement for Raw juice heating from 30 to 70°C.

\[
Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (70 - 30)}{550} = \text{6.545 Ts/hr.}
\]

2) Steam requirement for Sul. Jc. 1st heating from 65 to 90°C.

\[
Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (90 - 65)}{538.9} = \text{4.175 Ts/hr.}
\]

3) Steam requirement for Sul. Jc. 2nd heating from 90 to 103°C.

\[
Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (103 - 90)}{535} = \text{2.187 Ts/hr.}
\]

4) Steam requirement for clear juice heating from 95 to 103°C.

\[
Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (105 - 95)}{535} = \text{1.682 Ts/hr.}
\]

4) Evaporation in evaporator

\[
\frac{60 - 15}{60} \times 100 = 75.00 \%
\]
$4^{th}$ body $= X$
$3^{rd}$ body $= X + 6.545$
$2^{nd}$ body $= X + 6.545$
$1^{st}$ body $= X + 6.545 + 4.175$

\[ \text{Total evaporation} = 4X + 23.810 \]

\[ 4X + 23.810 = 75 \]
\[ X = 12.797 \]

Therefore, Exhaust required for quad =
\[ = 12.797 + 6.545 + 4.175 = 23.517 \text{ Ts/hr.} \]

Steam requirement for pan varies from 20 to 30 % on cane. Let us assume 25 % on cane.

Thus, total steam requirement---

For Sul. juice $2^{nd}$ heating $= 2.187$
Cl. juice $= 1.682$
Evaporator $= 23.517$
Pan $= 25.000$
Miscellaneous $= 5.000$

\[ \text{Total} = 57.386 \% \text{ on cane} \]
- Case VI: Steam required with vapour bleeding from 1st body of quad to Pans. (two pans i.e. 12.5% steam on pan flower) and S.Ji heater, & 2nd body of quad to R. Juice. Heater:

1) Steam / vapour requirement for V.L.J.H. From 30 to 40°C

\[
Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (40 - 30)}{566} = 1.590 \text{ Ts/hr.}
\]

2) Steam requirement for Raw juice heating from 40 to 70°C.

\[
Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (70 - 40)}{543} = 4.972 \text{ Ts/hr.}
\]

3) Steam requirement for Sul. Jc. 1st heating from 65 to 90°C.

\[
Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (90 - 65)}{538.9} = 4.175 \text{ Ts/hr.}
\]

4) Steam requirement for Sul. Jc. 2nd heating from 90 to 103°C.

\[
Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (103 - 90)}{535} = 2.187 \text{ Ts/hr.}
\]

5) Steam requirement for clear juice heating from 95 to 103°C.

\[
Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (105 - 95)}{535} = 1.682 \text{ Ts/hr.}
\]
7) Evaporation in evaporator

\[
\frac{60 - 15}{60} \times 100 = 75.00\% 
\]

\[
\begin{align*}
4^{th} \text{ body} &= X + 1.590 \\
3^{rd} \text{ body} &= X + 1.590 \\
2^{nd} \text{ body} &= X + 1.590 + 4.972 \\
1^{st} \text{ body} &= X + 1.590 + 4.972 + 4.175 + 12.500 \\
\end{align*}
\]

\[
\text{Total evaporation} = 4X + 32.979
\]

\[
4X + 32.979 = 75 \\
X = 10.505
\]

Therefore, Exhaust required for quad =

\[
= 10.505 + 1.590 + 4.972 + 4.175 + 12.500 = 33.742 \text{ Ts/hr.}
\]

Steam requirement for pan varies from 20 to 30 % on cane. Let us assume 25 % on cane.

Thus, total steam requirement---

\[
\begin{align*}
\text{For Sul.juice 2}\text{nd heating} &= 2.187 \\
\text{Cl. juice} &= 1.682 \\
\text{Evaporator} &= 33.742 \\
\text{Pan} &= 12.500 (\text{ Two pans}) \\
\text{Miscellaneous} &= 5.000 \\
\end{align*}
\]

\[
\text{Total} = 55.111\% \text{ on cane}
\]
7) Evaporation in evaporator

\[
\begin{align*}
60 - 15 &= \frac{\text{-------------}}{60} \times 100 = 75.00\% \\
4^{\text{th}} \text{ body} &= X + 1.590 \\
3^{\text{rd}} \text{ body} &= X + 1.590 \\
2^{\text{nd}} \text{ body} &= X + 1.590 + 4.972 \\
1^{\text{st}} \text{ body} &= X + 1.590 + 4.972 + 4.175 + 12.500 \\
\text{Total evaporation} &= 4X + 32.979
\end{align*}
\]

\[
4X + 32.979 = 75
\]

\[
X = 10.505
\]

Therefore, Exhaust required for quad =

\[
= 10.505 + 1.590 + 4.972 + 4.175 + 12.500 = 33.742 \text{ Ts/hr.}
\]

Steam requirement for pan varies from 20 to 30 % on cane. Let us assume 25 % on cane.

Thus, total steam requirement---

\[
\begin{align*}
\text{For Sul. juice } 2^{\text{nd}} \text{ heating} &= 2.187 \\
\text{Ct. juice} &= 1.682 \\
\text{Evaporator} &= 33.742 \\
\text{Pan} &= 12.500 \text{ (Two pans)} \\
\text{Miscellaneous} &= 5.000 \\
\text{Total} &= 55.111\% \text{ on cane}
\end{align*}
\]
Case VII) Steam required with vapour bleeding from 1st body of quintaple to S.J, heater, & 2nd body of quintaple to R.Juice. Heater:

1) Steam requirement for Raw juice heating from 30 to 70°C.

\[ Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (70 - 50)}{543} \approx 6.632 \text{ Ts/hr.} \]

2) Steam requirement for Sul. Jc. 1st heating from 65 to 90°C.

\[ Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (90 - 65)}{538.9} \approx 4.175 \text{ Ts/hr.} \]

3) Steam requirement for Sul. Jc. 2nd heating from 90 to 103°C.

\[ Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (103 - 90)}{535} \approx 2.187 \text{ Ts/hr.} \]

5) Steam requirement for clear juice heating from 95 to 103°C.

\[ Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (105 - 95)}{535} \approx 1.682 \text{ Ts/hr.} \]

4) Evaporation in evaporator

\[ \frac{60 - 15}{60} \times 100 = 75.00 \% \]

in 5th body = X
4th body = X
3rd body = X
2nd body = X + 6.632
1st body = X + 6.632 + 4.175

Total evaporation = 5X + 17.442
4X + 17.442 = 75
X = 11.51

Therefore, Exhaust required for quad =
= 11.51 + 6.632 + 4.175 + = 22.32 Ts/hr.

Steam requirement for pan varies from 20 to 30% on cane. Let us assume 25% on cane.

Thus, total steam requirement---

For Sul.juice 2nd heating = 2.187
Cl. juice = 1.682
Evaporator = 22.32
Pan = 25.00
Miscellaneous = 5.000

Total = 56.189% on cane
Case VIII) Steam required with vapour bleeding from V.C. to all pans; 1st body of quintaple to S.J heater, & 2nd body of quintaple to R.J Juice. Heater:-

1) Steam requirement for Raw juice heating from 30 to 70°C.

\[
Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (70 - 30)}{543} = 6.630 \text{ Ts/hr.}
\]

2) Steam requirement for Sul. Jc. 1st heating from 65 to 90°C.

\[
Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (90 - 65)}{538.9} = 4.175 \text{ Ts/hr.}
\]

3) Steam requirement for Sul. Jc. 2nd heating from 90 to 103°C.

\[
Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (103 - 90)}{535} = 2.187 \text{ Ts/hr.}
\]

4) Steam requirement for clear juice heating from 95 to 103°C.

\[
Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (105 - 95)}{535} = 1.682 \text{ Ts/hr.}
\]

5) Evaporation in evaporator:- The all vapours of V.C. are given to all pans therefore evaporation in quintapal 75 - 25 = 50% on cane
\[ \frac{60 - 15}{60} \times 100 = 75.00\% \]

- 5th body = X
- 4th body = X
- 3rd body = X
- 2nd body = X + 6.632
- 1st body = X + 6.632 + 4.175

\[ \text{Total evaporation} = 45X + 17.439 \]

\[ 5X + 17.439 = 50 \]
\[ X = 6.512 \]

Therefore, Exhaust required for quintuple =
\[ = 6.511 + 6.632 + 4.175 = 17.321 \text{ Ts/hr.} \]

Steam requirement for pan varies from 20 to 30% on cane. Let us assume 25% on cane.

Thus, total steam requirement---

- For Sul juice 2nd heating = 2.187
- Cl. juice = 1.682
- Evaporator = 17.321
- Pan = nil
- Miscellaneous = 5.000

\[ \text{Total} = 51.190\% \text{ on cane} \]
**Case IX** Steam required with vapour bleeding from V.C. to all pans; 1\textsuperscript{st} body of quad to S.J, heater, & 2\textsuperscript{nd} body of quad to R.Juice Heater :-( V.C + quad ).

![Diagram of steam flow](image)

1) Steam requirement for Raw juice heating from 30 to 70\(^0\)C.

\[
Q_I \times C_I \times \Delta T = \frac{100 \times 0.9 \times (70 - 30)}{543} = 6.630 \text{ Ts/hr.}
\]

2) Steam requirement for Sul. Jc. 1\textsuperscript{st} heating from 65 to 90\(^0\)C.

\[
Q_I \times C_I \times \Delta T = \frac{100 \times 0.9 \times (90 - 65)}{538.9} = 4.175 \text{ Ts/hr.}
\]

3) Steam requirement for Sul. Jc. 2\textsuperscript{nd} heating from 90 to 103\(^0\)C.

\[
Q_I \times C_I \times \Delta T = \frac{100 \times 0.9 \times (103 - 90)}{535} = 2.187 \text{ Ts/hr.}
\]

4) Steam requirement for clear juice heating from 95 to 103\(^0\)C.

\[
Q_I \times C_I \times \Delta T = \frac{100 \times 0.9 \times (105 - 95)}{535} = 1.682 \text{ Ts/hr.}
\]

4) Evaporation in evaporator:- The all vapours of V.C. are given to all pans therefore evaporation in quintapal 75 -25 = 50 % on cane

\[
\frac{60 - 15}{60} \times 100 = 75.00 \%
\]
4th body = X
3rd body = X
2nd body = X + 6.632
1st body = X + 6.632 + 4.175

Total evaporation = 4X + 17.439

4X + 17.439 = 50
X = 8.140

Therefore, Exhaust required for quintuple =
= 8.140 + 6.632 + 4.175 = 18.945 Ts/hr.

Steam requirement for pan varies from 20 to 30 % on cane. Let us assume 25 % on cane.

Thus, total steam requirement---

For Sul.juice 2nd heating = 2.187
Cl. juice = 1.682
Vapoue Cell = 25.000 (i.e pan requirement)
Evaporator = 18.945
Pan = nil
Miscellaneous = 5.000

Total = 52.814 % on cane
• Case X ) Steam required with vapour bleeding from D.E.V.C. 1st body to low grade pan i.e C/Mc. (6 % on cane.) and from 2nd body to high grade pans i.e. B/Mc., A/Mc. (19 % on cane); Similarly 1st body of quad to S.J. heater, & 2nd body of quad to R.Juice. Heater :- (D.E.V.C. + quad.)

1) Steam requirement for Raw juice heating from 30 to 70°C.
\[ Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (70 - 30)}{543} = 6.630 \text{ Ts/hr.} \]

2) Steam requirement for Sul. Jc. 1st heating from 65 to 90°C.
\[ Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (90 - 65)}{538.9} = 4.175 \text{ Ts/hr.} \]

3) Steam requirement for Sul. Jc. 2nd heating from 90 to 103°C.
\[ Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (103 - 90)}{535} = 2.187 \text{ Ts/hr.} \]

4) Steam requirement for clear juice heating from 95 to 103°C.
\[ Q_j \times C_j \times \Delta T = \frac{100 \times 0.9 \times (105 - 95)}{535} = 1.682 \text{ Ts/hr.} \]
5) Evaporation in D.E.V.C.: From 1st Body D.E.V.C. vapours goes to low grade pan i.e. C/Mc. Pans (6% on cane) and next body of D.E.V.C. From 2-nd body of D.E.V.C. all vapours goes to high grade pans i.e. A/Mc. & B/Mc. (19% on cane)

Therefore, evaporation in D.E.V.C. 1st body = 6 + 19 = 25
In D.E.V.C. 2nd body = 19
Therefore, total evaporation in D.E.V.C. = 25 + 19 = 44
Hence out of total evaporation 75%, 44% evaporation done in D.E.V.C.

Therefore, evaporation in quadruple = 75 - 44 = 31%

\[
\begin{align*}
60 - 15 &= \frac{60 - 15}{60} \times 100 = 75.00\% \\
4^{th} \text{ body} &= X \\
3^{rd} \text{ body} &= X \\
2^{nd} \text{ body} &= X + 6.632 \\
1^{st} \text{ body} &= X + 6.632 + 4.175 \\
\text{Total evaporation} &= 4X + 17.439 \\
4X + 17.439 &= 31 \\
X &= 3.390
\end{align*}
\]

Therefore, exhaust required for quadruple =
\[
= 3.390 + 6.632 + 4.175 = 14.199 \text{ Ts/hr.}
\]

Steam requirement for pan varies from 20 to 30% on cane. Let us assume 25% on cane. That is full filled from D.E.V.C.

Therefore, exhaust required for D.E.V.C. = 25.000 Ts/Hr.

Thus, total steam requirement---

For Sul. juice 2nd heating = 2.187
Cl. juice = 1.682
Evaporator = 14.199
D.E.V.C. = 25.000
Pan = nil
Miscellaneous = 5.000

\[
\begin{align*}
\text{Total} &= 48.068 \text{ % on cane}
\end{align*}
\]