UNDERSTANDING OF OUR AMMONIA COOLING SYSTEM

- We have 6 ammonia compressors for the Chilled water system (IBT)
- But, the ammonia flow lines of IBT compressors and other compressors are connected.
- This interconnection of ammonia makes difficulty to get the exact engineering figures separately
- Approximate water holding capacities of each IBT is 29000, 29000 and 49000
- The forward chilled water flow is approximately 68000 Ltrs/Hr. with the pressure of 2.6 Bar.

Remarks: The calculations and findings in this report are based on the currently available data, neglecting the different losses and the data collected from the concerned personals. To get more accurate calculation values, we need more data and time to collect each. The numerical values may vary since we have not considered the losses.

IN THIS REPORT, WE ARE GOING TO FIND OUT THE AVERAGE CAPACITY OF OUR COOLING SYSTEM. BASED ON, WE WILL INTREPRET WHETHER CAN WE ACHIEVE THE COOLING REQUIREMENT IN SUMMER, ALSO WHY WE ARE NOT GETTING REQUIRED OUTLET TEMPERATURE IN THE PROCESSING PLANTS EVENTHOUGH THERE IS GOOD TEMPERATURE IN THE ICE BUILDING TANKS (IBTs).

ESTIMATION OF COOLING CAPACITY OF EXISTING AMMONIA COMPRESSOR SYSTEM

Normally around 1.2 hrs of time is needed to reduce the temperature of newly filled water of around 30^{o}C to 1 ^{o}C in the IBTs by running all the compressors.

By the equation,

$Q = m\ C_p\ \Delta T$

Here, Q = Energy needed to cool the water

m = mass flow

C_p = Specific heat of water

ΔT = Temperature difference

We can consider the energy requirement separately for each of 3 IBTs.

Tank	IBT Backward Temp (^{o}C)	IBT Forward Temp (^{o}C)	Water Temperature Reduced (^{o}C)	Quantity of Water (Ltrs)
3	30	19	11	29000
2	19	8	11	29000
1	8	1	7	49000
			Total Ltrs. Of water	107000

So,

total amount of water = 107000 ltrs. (m)

Specific heat of water = 4190 J/Kg. ^{o}C (C_p)

To find the final water temperature of total tanks, Let's use the formula

$FT = (V_1T_1+ V_2T_2+ V_3T_3)/ V_1+ V_2+ V_3$

FT = Final temperature of mixture

V = Volume of each component

T = Temperature of each component

Final Temperature after 1.2 hour would be = 7.78^{o}C, temperature difference = 30 – 7.78 = 22.22 ^{o}C

Then, the total energy required, Q = 107000 Kg X 4190 J/Kg. ^{o}C X 22.22 ^{o}C = 9961892600 J = 2767 KW

So, by the calculation, total power of our ammonia system (average capacity) ≈ 2300 KWH

Note *: The values are approximate, considering good ambient conditions and transfer losses*

CALCULATION OF FACTORY COOLING LOADS

Cooling load can be calculated by two ways

1. By considering the product/material in and out temperatures and
2. Indirectly, by taking the forward and return temperature difference of cooling water

By taking the forward and return temperature difference of cooling water

Let's take the average daily temperature data from summer and winter

SUMMER			
Date	**IBT Temp (°C)**		**Plant out Temp. (°C)**
	Forward	**Return**	
01-08-22			
02-08-22			
03-08-22			
04-08-22			
05-08-22			
06-08-22			
07-08-22			
08-08-22			
09-08-22			
10-08-22			
11-08-22			
12-08-22			
13-08-22			
14-08-22			
15-08-22			
16-08-22			
17-08-22			
18-08-22			
19-08-22			
20-08-22			
21-08-22			
22-08-22			
23-08-22			
24-08-22			
25-08-22			
26-08-22			
27-08-22			
28-08-22			
29-08-22			
30-08-22			
31-08-22			
Average	**5**	**28**	**9**

WINTER			
Date	**IBT Temp (°C)**		**Plant out Temp. (°C)**
	Forward	**Return**	
16-12-22			
17-12-22			
18-12-22			
19-12-22			
20-12-22			
21-12-22			
22-12-22			
23-12-22			
24-12-22			
25-12-22			
26-12-22			
27-12-22			
28-12-22			
29-12-22			
30-12-22			
31-12-22			
01-01-23			
02-01-23			
03-01-23			
04-01-23			
05-01-23			
06-01-23			
07-01-23			
08-01-23			
09-01-23			
10-01-23			
11-01-23			
12-01-23			
13-01-23			
14-01-23			
15-01-23			
	2	**21**	**8**

***Note**: The values are average and taken most stable values as per the available records and only considered the milk/yoghurt for the better understanding.*

Now, Let's calculate the cooling load in both summer and winter by the above data

By the equation,

$$Q = m\, C_p\, \Delta T$$

Production (Factory) heat removed in summer:

Tank	IBT Backward Temp (°C)	IBT Forward Temp (°C)	Temperature Raised (°C)	Flow rate of Water (Ltrs./h)	Heat Removed (Refrigeration Load) KWH
3	28	16	12	68000	950
2	16	9	7	68000	554
1	9	5	4	68000	317
				Total heat removed =	**1820**

Production (Factory) heat removed in winter:

Tank	IBT Backward Temp (°C)	IBT Forward Temp (°C)	Temperature Raised (°C)	Flow rate of Water (Ltrs./h)	Heat Removed (Refrigeration Load) KWH
3	21	11	10	68000	791
2	11	5	5	68000	396
1	5	1	4	68000	317
				Total heat removed =	**1504**

From the above tables let's interpret:

- During the summer, existing cooling system can remove 1820KW/h heat from the factory heat sources
- During summer, there will be reduction of ≈21% cooling capacity due to the reduced condenser efficiency
- During winter, we are not utilizing the maximum capacity of cooling system

If we increase the flow rate by 20000LPH through the pasteurizer, separately, Cooling load in winter:

Cooling of milk expected from 10 to 6 °C (4 °C reduction)

Maximum expected flow rate of milk through pasteurizer (2 plants) = 15000 LPH

Then the expected elevation of temperature of chilled water:

$Q_{\text{Heat Loss of milk}} = Q_{\text{Heat gain of Chilled water}}$ (by neglecting the losses)

15000 Ltr. X 1.04 Kg/Ltr. X 3900 J/Kg. °C X 4 °C = 20000 Kg X 4190 J/Kg. °C X $(T_2\text{-}T_1)$ °C

$T_2\text{-}T_1 \approx 3^\circ C$

Then the final effective elevation of temperature in the IBT will be,

$T_{\text{IBT Final}}$ = (20000 Ltrs. X 24°C + 68000 Ltrs. X 21°C)/ (20000 Ltrs.+ 68000 Ltrs.) = 21.7 °C

By considering +5% variation due to increase in flow rate through other high cooling load plants.

The IBT water temperature would be ≈ 24 °C

Tank	IBT Backward Temp (°C)	IBT Forward Temp (°C)	Temperature Raised (°C)	Flow rate of Water (Ltrs./h)	Maximum Heat Removed (Refrigeration Load) KWH
3	24	13	10	88000	1127
2	13	7	5	88000	615
1	7	1	4	88000	512
				Total heat removed =	**2253**

From the above table, we can interpret:

- Cooling can be achieved (milk/ yoghurt, in pasteurizer) by connecting completely separate IBT water line of chilled water around 20000 Ltrs./Hr. flow rate (depends product mixing temperature).
- This couldn't be guaranteed in summer season since the above data made with the assumption of winter climate for the ammonia plant condenser.
- During summer, let's say the cooling capacity will be 1780KWH (by assuming efficiency reduction of condenser by a factor of 21%) which means we need an additional cooling source to make up the 470KWH with the above cooling line modification.

MAJOR COOLING REQUIREMENT OF EQUIPMENTS/MACHINES

Sl. No.	**Equipment/ Machine**	**Capacity** (LPH)	**Chilled water Cooling Starts from** (^{o}C)	**Required Outlet Temp.** (^{o}C)	**Temp. Difference** (^{o}C)
1		1200	105	<35	70
2		1200	105	<35	70
3		5000	65	<7	58
4		10000	55	<7	48
5		2500	55	<7	48
6		6500	60	<25	35
7		5000	60	<25	35
8		-	110	75	35
9		2800	55	<25	30
10		1200	50	<25	25
11		4200	35	<15	20
12		10000	35	<20	15
13		3400	35	20	15
14		-	35	28	7
15		-	10	7	3
16		-	-	-	

From the above table, let's interprets:

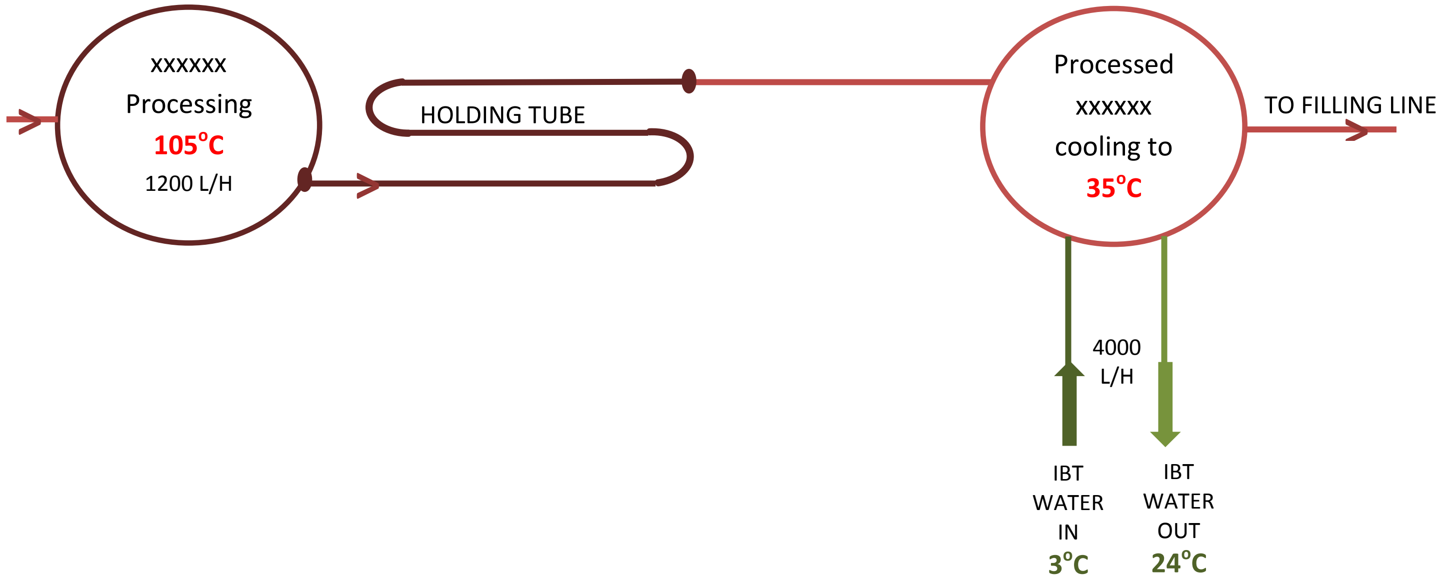
- xxxxxx production requires heavy direct temperature reduction of product, around 70^{o}C.

SUGGESTIONS TO IMPROVE COOLING EFFICIENCY/ REDUCE RESOURCE LOSSES

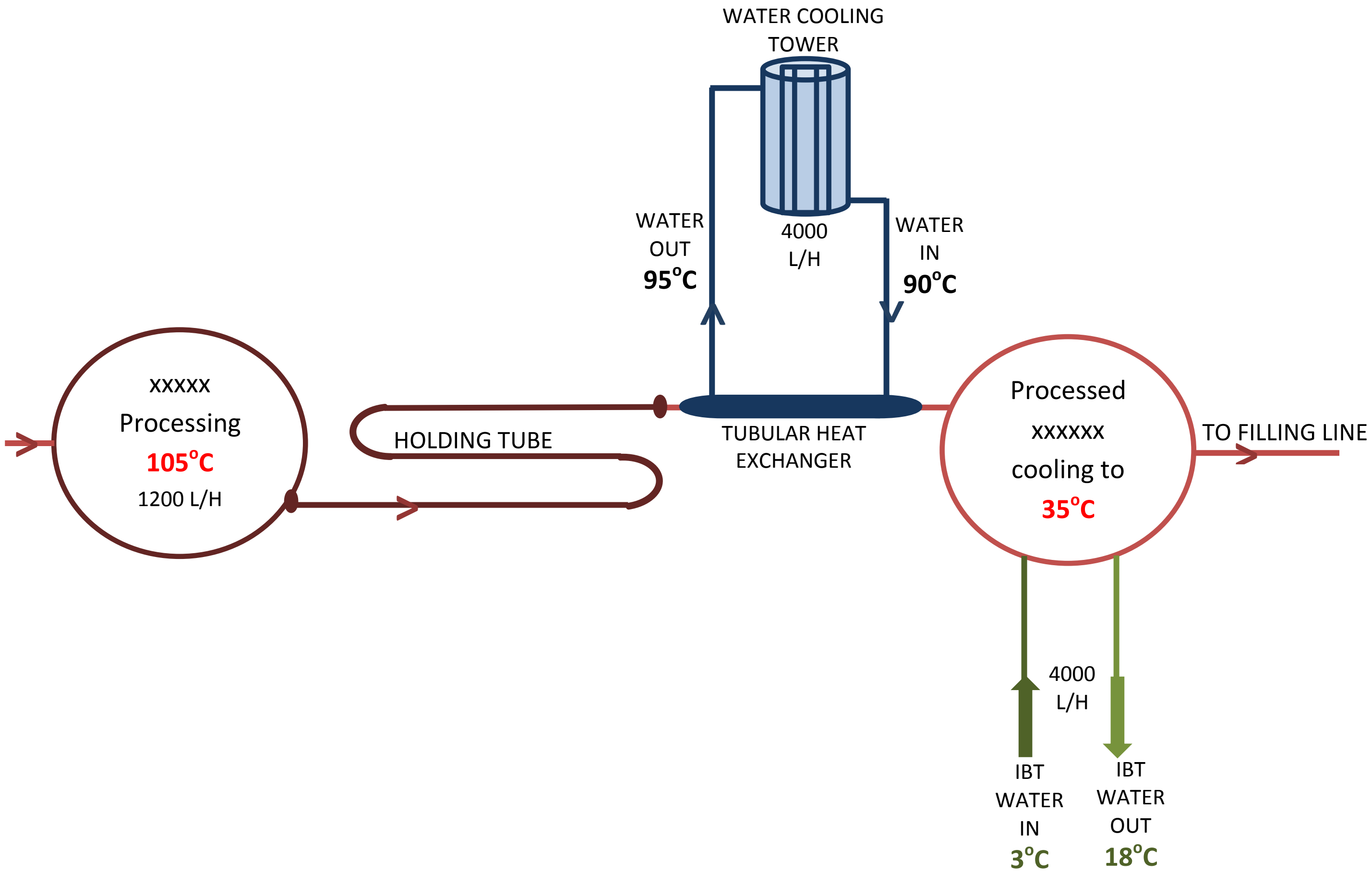
1. Additional Cooling Tower for xxxxxx precooling by water

Since there is a huge cooling requirement in xxxxxx plant, direct the product flow through an additional tubular heat exchanger with an additional cooling tower (primary cooling by normal circulating water)

Schematic diagram of existing xxxxxx processing plant (one type of vegetable concentrate having 26°Brix)



After suggested modification



HIGLIGHTS

- **During winter, we may get required outlet temperature for milk/ yoghurt processing by increasing the chilled water flow only through the milk/ yoghurt processing plants by maintaining the current outlet temperature for remaining all items.**
- **During summer, our cooling system is not enough to handle the entire cooling load.**
- **We can increase the cooling efficiency by reducing many energy losses.**