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OPTIMIZATION OF DAIRY PLANT FUNCTIONALITY: INSTALLATION OF COOLING TOWERS IN THE EVAPORATIVE SECTION

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Abstract:

The study of dairy plant describes a study to optimize the functionality of dairy plant by installation of cooling towers. It deals with the replacement of spray pond by cooling tower and to analyze temperature difference between them. This research was under taken in order to increase the efficiency of evaporator and dryer section which indirectly increases the efficiency of dairy plant. It is well known fact that the Efficiency of any Organization depends on the Production rate as efficiency is nothing but the ratio of output quantity to the Input quantity. The operation of cooling towers relies on the fundamental principle of evaporation, wherein a fraction of the water is transformed into vapor and subsequently dispersed into a moving air stream. This air stream, now laden with water vapor, is then expelled into the atmosphere. As a direct outcome of this process, the temperature of the remaining water is substantially reduced.. The main intent of the industry is to inculcate the good manufacturing practices by considering the environmental safety. A research investigation was undertaken to identify the optimal a chiller plant with multiple chillers and cooling towers, getting the condenser water temperature just right is key. If it's too high, the plant uses more energy than it needs to. If it's too low, the plant might not be able to cool properly. Finding the optimal temperature setpoint can make a big difference in how efficiently the plant runs. The evaporative section of a dairy plant is a critical component of the overall production process. However, it can also be a significant source of heat generation, which can negatively impact the plant's performance and efficiency. The installation of cooling towers in the evaporative section can help to mitigate this issue by providing an efficient means of heat dissipation. Cooling towers work by using evaporation to cool the water, which is then circulated through the plant to absorb heat. By installing cooling towers, dairy plants can improve their heat transfer processes, reduce energy consumption, and increase their overall efficiency.

Keywords: Optimize, Efficiency, Cooling towers

Introduction:

Cooling towers are an essential component in numerous dairy plants, playing a critical role in heat rejection. The primary objective of a cooling tower is to dissipate hotness into the

atmosphere, thereby providing a cost-effective and reliable means of eliminating substandard heat from cooling water. To facilitate this process:

- 1) Makeup water is utilized to compensate for water loss due to evaporation.
- 2) Heat from exchangers is distributed to the cooling tower.
- 3) The water is cooled through the rejection of heat into the atmosphere.
- 4) The cooled water is then recirculated back to the exchangers for more cooling.

The operation of cooling towers relies on the principle of evaporation, wherein a portion of the water is transformed into vapor and subsequently dispersed into a moving air stream. This air stream, now laden with water vapor, is then expelled into the atmosphere. As a direct effect of this process, the temperature of the remaining water is substantially reduced. The heat transfer mechanism within the cooling tower involves the transfer of heat between the water and air, facilitated by direct contact and evaporation.

Cooled water is a vital component in various industrial and commercial applications, including air conditioning systems, manufacturing processes, and power generation. Cooling towers are specialized devices designed to decrease the temperature of a water stream by removing heat from the water and releasing it into the atmosphere. This process is achieved through the principles of evaporation, where a portion of the water is vaporized into a affecting air stream and subsequently discharged into the atmosphere. As a result, the remaining water undergoes significant cooling. Cooling towers offer a more efficient and cost-effective solution compared to devices that rely solely on air to reject heat, such as radiators used in automotive applications.

Terms & Definitions

Evaporation Section - Evaporation suggests that removal of water by boiling an answer. It's a method during which the liquid is gaseous, or gasified into a gas going away the merchandise with smallest wetness.

Evaporation is AN initial step within the drying method. It makes the ultimate product additional economical and appropriate for final drying. Evaporation undergoes within the three completely different evaporators during this section that ar as follows:

- **Mineral Evaporator:** it's a 3-effect evaporator. Product: dairy farm bleach (Fat %: five-hitter, 10%, 15%, 18%, and 19%)
- **Baby Food Evaporator:** it's a 5-effect evaporator. Products: SMP & WPC
- **Permeate Evaporator:** it's a 7-effect evaporator. Product: disaccharide

Objectives:

- To increase the general potency of plant (powder production).
- To eliminate the labor works.

- To analyze problems and causes associated with additional consumption of steam.
- To overcome the issues associated with finance.
- To replace natural cooling by artificial cooling.
- Replacement of Spray pool by Cooling Tower (CT).

Theoretical Background:

Components of a cooling system

- ❖ The basic parts of a cooling system embrace the frame and casing, fill, cold-water basin, drift eliminators, air inlet, louvers, nozzles and fans. These area units delineate below.
 - Frame and Casing:** The structural framework of a cooling tower is comprised of a frame and casing, which work in tandem to provide support for the tower's various components. The frame serves as the primary structural element, providing a foundation for the external additions, motors, fans, and other parts. In minor designs, such as certain fiber units, the casing and frame may be integrated, eliminating the need for a separate frame and casing.
 - ❖ **Fill:** The heat transfer procedure in cooling towers is facilitated by the usage of fills, which are typically made of plastic or wood. These fill expansion the connection among water and air, enabling more efficient heat transfer. There are two primary types of fills used in cooling towers, each designed to optimize heat transfer in different applications.
 - ❖ **Splash Fill:** It is a specific type of fill employed in cooling towers, designed to optimize heat transfer through a unique water distribution system. In this configuration, water flows over multiple layers of horizontal splash bars, resulting in the fragmentation of water into smaller droplets. Concurrently, the fill surface becomes wetted, further enhancing the heat transfer process. Interestingly, studies have shown that plastic splash fills revelation higher heat transfer performance compared to wooden splash fills.
 - ❖ **Film Fill:** Film Fill is a specific type of fill employed in cooling towers, designed to optimize heat transfer through the creation of a thin water film. This film is formed as water flows over thin, narrowly spaced plastic exteriors, which can be flat, corrugated, or feature various patterns. The Film Fill design enables efficient heat transfer between the water and air, while also providing a more economical solution compared to Splash Fill. Furthermore, Film Fill can achieve comparable heat transfer performance to Splash Fill, but in a significantly smaller volume.
 - ❖ **Cold-Water Basin:** The cold-water basin is a critical component of a cooling tower, typically situated at or near the base of the structure. Its primary function is to collect the cooled water that has flowed despondent through the tower and fills. The basin is designed with a sump or low point to facilitate the efficient discharge of cold water. The positioning of the cold-water basin can vary depending on the tower design. In some configurations, the basin is located below the entire fill, while in others, such as enforced flow counter flow designs, the water at the bottom of the fill is directed to a peripheral

trough that serves as the cold-water basin. This design variation allows for greater flexibility in tower design and operation.

- ❖ **Drift Eliminator:** Drift eliminators are a crucial component in cooling tower design, serving to minimize water loss and prevent environmental contamination. These eliminators capture water droplets that are captured within the air stream, which would otherwise be lost to the atmosphere. By removing these droplets from the air stream, drift eliminators help to reduce the amount of water lost through drift, thereby conserving this valuable resource.
- ❖ **Air Inlet:** The air inlet work for as the primary entry point for air flowing into a cooling tower. The configuration of the air inlet can differ significantly depending on the specific tower design. In a cross-flow design, the air inlet often occupies an intact side of the tower, allowing for a large volume of air to enter the tower. In contrast, counter-flow designs typically feature the air inlet located at the lowest or low on the adjacent of the tower, which helps to optimize airflow and heat transfer.
- ❖ **Louver:** Louvers are an essential component in many cross-flow cooling tower designs, typically installed at the air inlet to regulate airflow and prevent water loss. The primary function of louvers is to ensure uniform airflow into the fill, which helps to optimize heat transfer and tower performance. Additionally, louvers play a crucial role in retaining water within the tower, minimizing the risk of water escape and reducing the environmental impact of the tower. In contrast, several counter-flow tower projects do not require louvers, as their configuration inherently promotes uniform airflow and water retention.
- ❖ **Nozzle:** Nozzles are a critical component in cooling towers, responsible for spraying water to wet the fill. Achieving constant water supply at the top of the fill is vital to ensure proper wetting of the complete fill surface. This is essential for optimizing heat transfer and maintaining the overall efficiency of the cooling tower. Nozzles can be mounted in a fixed position, spraying in a circular or square pattern, or they can be integrated into a rotating assembly, as found in some circular cross-flow towers. This rotating design enables the nozzles to cover the entire fill area, ensuring uniform water distribution and optimal cooling tower performance.
- ❖ **Fans:** Cooling towers rely on fans to facilitate airflow and enhance heat transfer. Two primary types of fans are employed in cooling towers: axial and centrifugal fans. Propeller fans are commonly used in induced draft towers, where they provide a high volume of airflow at a relatively low pressure. In contrast, forced draft towers often utilize both propeller and centrifugal fans, depending on the specific design requirements. The type of propeller fan used is typically determined by its size, with either fixed or variable pitch designs employed. Variable pitch blades offer the advantage of adjustable airflow in response to changing load conditions, allowing for optimized tower performance and energy efficiency.

- ❖ **Spray Lake:** In the absence of a dedicated cooling system, cooling was previously achieved through the use of a Spray Lake. This artificial cooling method relied on a large water reservoir, known as a Spray Lake, which had a holding capacity of 800,000 liters. The Spray Lake featured a complex network of pipes arranged in a square pattern, through which water was circulated to facilitate cooling. This artificial cooling method was used to cool equipment and processes before the installation of a more modern and efficient cooling system.

“Optimization of Water-Cooled excitation Plant System Operation” by Senhuang, this paper defines a case study of the model based mostly condenser water temperature point management for a excitation plant with multiple chillers & cooling towers. A model-based control strategy was established to optimize the condenser water temperature set point for a chiller plant with multiple chillers and cooling towers. The plant was modeled using the Modelica Building Library, which allowed for accurate representation of the system's behavior. The regulatory controller and local loop control were both modeled to ensure realistic simulation of the system. The total energy consumption and computational times under different optimization methods were compared. The results showed that daily optimization can achieve similar energy savings to hourly optimization, but with significantly less computational time. This finding has important implications for the design and operation of chiller plants.

“Analysis of Forced Draft cooling system Performance victimization Annoys Fluent Software”, given at International Journal of analysis in Engineering & Technology by P. Mohamed. In this project the cooling system performance has been analyzed by varied air body of water parameters with completely different air body of water angles & by attaching a nozzle in air body of water. The cooling system analyzed here is employed specifically for little scale industries, that is forced draft counter flow cooling system with single module capacities from ten to a hundred cooling tons. On scrutiny the effectiveness values of cooling system models, the cooling system with air body of water pipe at zero degree & the cooling system with air body of water pipe inclined at thirty degrees regarding each horizontal & vertical axis have nearly same effectiveness.

“Optimizing Heat Recovery by group action Industrial Heat Pumps with different Energy Systems” by Kenneth Hoffmann depicts to minimize the carbon footprint and maximize energy output per metric weight unit of fuel, we've got highlighted however industrial heat pumps together with biomass/waste CHP, waste heat recovery, and heating technologies – will optimize total system performance. To optimize the utilization of enormous areas of star panels, it's necessary to style hot-water storage tanks and uses them together with an apparatus. The warmth pump will pre cool the water to the star panels and boost the hot-water provide temperature to the required level once there's not decent sunshine.

“Applying Cleaner Production and Optimizing Heat method Operations In dairy farm process Plants”, given in school of commercial Sciences & Technology national capital Institute Of

Technology, By P. Muredzi At, Harare, Zimbabwe. This comprehensive review paper delves into the complexities of cleaner production in the dairy industry, with a specific focus on optimizing heat processes. The paper provides an in-depth examination of various methodologies and approaches aimed at improving production processes, reducing environmental impact, and promoting sustainability. A case study on sterilization is presented, highlighting the benefits and challenges of implementing cleaner production practices. The paper concludes by offering actionable recommendations for dairy plants seeking to adopt cleaner production methods. Cleaner production is a forward-thinking approach that seeks to design and operate industrial processes, as well as develop and produce products and services, in a way that minimizes environmental harm.

Research Methodology

Research Statement

A research statement is a concise description of a complex problem or challenge that a researcher aims to address. In the context of this study, the research problem is the high temperature issue faced by the organization, which results in increased steam requirements and negatively impacts the company's efficiency and financial performance. This problem is further complicated by the need to conserve water resources, which is essential for sustainable operations. To address these interconnected challenges, a comprehensive study of the cooling tower is necessary. This study aims to investigate the current performance of the cooling tower, identify areas for improvement, and develop strategies to optimize its operation and enhance the overall efficiency of the plant.

As in this study researcher is going to replace spray pond by cooling tower whose sump capacity is 2 lack liters whereas the capacity of spray pond is 8 lacks. Nearly we are saving 6 lacks liters of water. In order to expand the store of company, it need more space, this was also one of the reasons we need to replace it.

Research Design:

Exploratory Research: In Exploratory type of design is adopted for this research. The exploratory type of research is a preliminary investigation that is typically conducted when a problem or research question has not been clearly defined. This type of research is essential in the initial stages of the research process, as it enables the researcher to gain a deeper understanding of the problem, its context, and its various dimensions. By conducting exploratory research, the researcher can familiarize themselves with the problem, identify key issues, develop a more focused research question, and design a more effective research methodology.

Data Analysis and Interpretation:

Primary data refers to original data collected by the researcher or investigator through direct observation, experimentation, or surveys. This type of data collection is considered primary because it involves the collection of new data that has not been previously published or

analyzed. Primary data collection can be a costly and time-consuming process, requiring significant financial resources, energy, effort, and time. However, it provides researchers with unique and original insights that can be tailored to their specific research objectives.

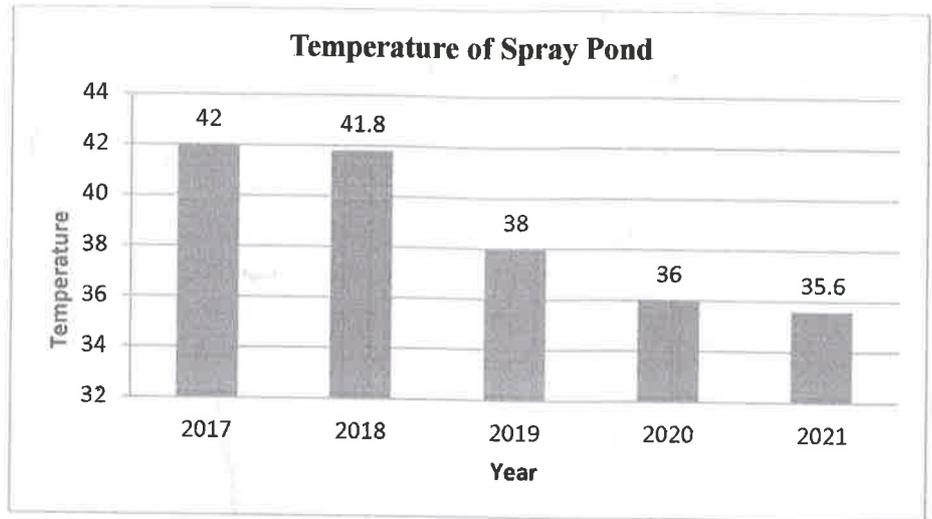
Break down Analysis Sheet

A structured breakdown analysis sheet is a systematic tool used to identify, record, and analyze the causes of stoppages in the packing machine. This comprehensive sheet is designed to provide a detailed understanding of the frequency, duration, and impact of machine stoppages. The sheet contains a list of potential reasons for machine stoppages, as well as columns to record the actual number of breakdowns, the resulting waste generated, and any additional relevant information. By maintaining this sheet, operators and maintenance personnel can track and analyze the performance of the packing machine, identify areas for improvement, and implement targeted interventions to minimize downtime, reduce waste, and optimize production efficiency.

Day No.	FEED TEMP.		FEED RATE	SPRAY POND		Day No	FEED TEMP.		FEED RATE	SPRAY POND	
	IN LET	OUT LET	X10000 LPH	IN LET	OUT LET		IN LET	OUT LET	X10000 LPH	IN LET	OUT LET
1	48.3	78	28.5	34.5	51.3	16	51.2	92	28.6	36.1	50.2
2	48.2	85	27.2	35.2	52.5	17	54.4	82	27.8	34.8	50.8
3	48.0	83	28	35.4	52.8	18	52.1	76	28.8	34.2	51.3
4	49.3	84	28.8	35.7	51.8	19	50.9	79	27.2	34.5	52.5
5	49.7	89	29.5	36.8	50.6	20	50.5	85	28.5	35.2	52.8
6	49.9	79	28.2	37.5	49.7	21	52.6	88	27.2	35.4	51.8
7	51.2	76	28	35.2	49.8	22	52.6	80	28	35.7	50.6
8	53.2	89	28	35.9	50.6	23	51.2	93	28.8	36.8	49.7
9	53.9	92	28	37.9	53.2	24	49.9	87	29.5	35.7	49.8
10	52.4	80	28.4	37.8	51.9	25	51.4	75	26.5	34.3	50.6
11	54.7	75	27	35.4	48.4	26	53.8	78	29.5	34.8	51.9
12	52.3	77	28.8	34.4	48.8	27	54.1	79	29.5	36.4	49.8
13	51.9	82	29	35.2	49.5	28	54.7	83	28	35.7	49.3
14	52.2	85	29	34.9	50.3	29	55.6	87	28.4	37.1	50.5
15	51.9	89	27.5	34.1	51.2	30	55.1	85	28.5	36.6	50.2

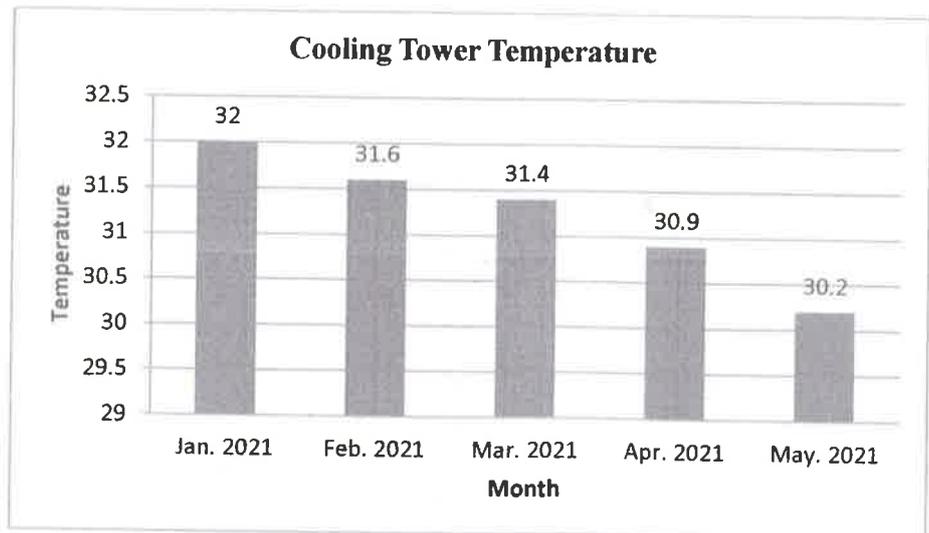
Spray Pond Cooling Temperature:

The highest temperature of the spray pond was in the year 2017 & 2018 while the lowest temperature was in the current year 2021. Also, it is observed that there is temperature variation is 42 to 35.6 degree from year 2017 to 2021. This temperature variation was due to installation of one small C.T.



Cooling Tower Temperature:

The highest temperature of the Cooling tower was in the month January while the lowest temperature was in the month May. The New Cooling Tower project nearly has achieved the desired temperature.

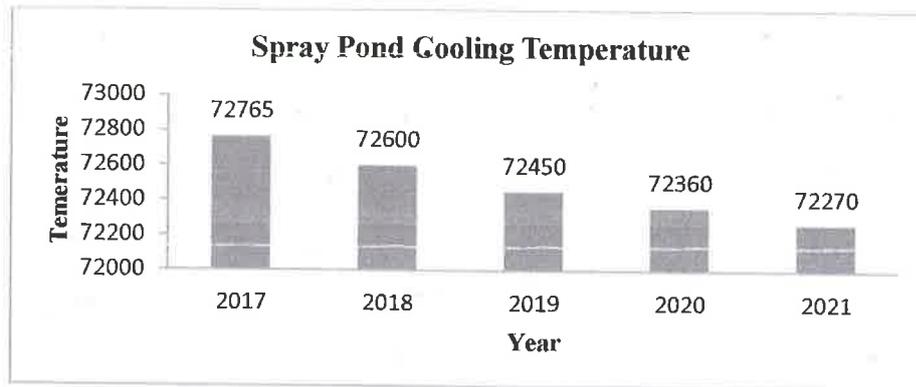


Steam Consumption due to Spray Pond

The highest steam consumption by Evaporator & dryer was in the year 2017 i.e 72765 while the lowest steam consumption was in the year 2021 i.e 72270, it was due to installation of small C.T

Cost of Steam Consumption per Kg = 3.5 Rs.

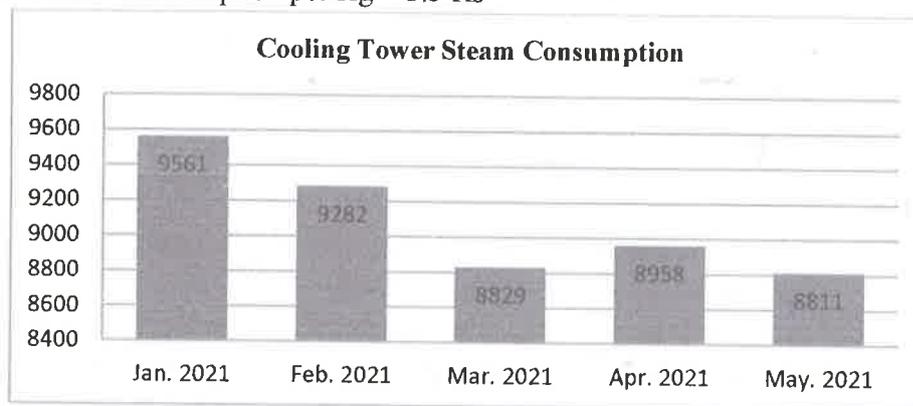
Cost of Steam Consumption last year i.e 2021 = $72270 \times 3.5 = 252945$ Rs.



Steam Consumption due to Cooling Tower

It is clear that the since installation of new C.T, highest steam consumption by Evaporator & dryer was in the month Jan 2021 i.e 9561 while the lowest steam consumption was in the month May 2021 i.e 8811.

Cost of Steam Consumption per Kg = 3.5 Rs



Implementing a routine preventive maintenance program for cooling towers can yield significant benefits, including energy cost savings of up to 15%. Regular maintenance not only helps to conserve water but also extends the operating life of cooling equipment. Neglecting cooling tower maintenance can lead to increased energy costs, with every 2°F rise in leaving water temperature resulting in a 6% increase in energy expenditure. Conversely, a well-maintained cooling tower will continue to operate at its initial optimal level, minimizing energy costs.

Findings:

- By replacement of spray pond by cooling tower, first of all 6 lakh liters of water is saved as sump capacity of spray pond was 8 lakh liters whereas cooling tower sump is 2 lakh liters.

- Raw water rate by means of tanker is 220 rupees per 10000 liters. According to these rates nearly 41800000 rupees of raw water have been saved.
- Also, from previous chapter we have observed that steam consumption due to the spray pond was quite large whereas steam consumption due to cooling tower is very less as compared with spray pond which directly has saved nearly about 1 to 1.5 crores of rupees.
- Also, maintenance cost as well as labor cost has been decreased due to replacement of spray pond.
- Due to the decreased in cooling water temperature, the steam required by the evaporator & dryer section have been decreased which ultimately results in the increased in the production rate.
- Major break down occurs due to the maintenance of pumps as well as maintenance of cooling towers.
- Break down also occurs due to the empty of sump of cooling tower.
- Efficiency of cooling tower affects by quality of water. So certain parameters like T.D.S (Total Dissolved Solids), T.S.S (Total Suspended Solids), Hardness, PH etc. have to be checked daily and have to maintain in a certain limit. Blow down every day at least 2 hours should be given in order to increase the performance of cooling tower.

The incorporation of cooling towers in the evaporative section of a dairy plant can have a significant impact on its overall performance and efficiency. Some of the key benefits of this installation include:

- Enhanced heat transfer processes: Cooling towers facilitate efficient heat transfer, allowing the plant to operate at optimal temperatures.
- Reduced energy consumption: By minimizing heat gain and maximizing heat dissipation, cooling towers help reduce energy consumption, leading to lower operational costs.
- Increased plant performance: The efficient cooling provided by cooling towers enables dairy plants to operate at higher production capacities, improving overall plant performance.
- Efficient heat dissipation: Cooling towers provide an efficient means of heat dissipation, minimizing the risk of overheating and equipment damage.
- Environmentally friendly: Cooling towers utilize evaporation to cool water, providing an environmentally friendly solution.
- Customization options: Cooling towers can be customized to meet the specific needs of a dairy plant, ensuring optimal performance and efficiency.

Suggestions:

To ensure the optimal performance and longevity of a cooling tower, it is essential to implement a comprehensive maintenance schedule. The following eight maintenance tips are crucial for maintaining the efficiency and reliability of a cooling tower:

1. Conduct a visual inspection and listen for unusual noises - Conduct a thorough visual inspection of the cooling tower to identify any potential issues or areas of concern. Listen for any unusual noises or vibrations that may indicate a problem.
2. Follow proper lockout procedures and disconnect motor switches - Prior to commencing any maintenance work, ensure that proper lockout procedures are followed, and motor switches are disconnected to guarantee a safe working environment.
3. Clean debris from strainers. - Examine and clean debris from strainers to prevent excess materials from entering the system and causing damage or inefficiencies.
4. Inspect the water distribution system - Inspect the water distribution system to ensure that it is functioning correctly and not causing any scale buildup or dry areas over the fill coil section.
5. Flush dirt and debris from the cold-water basin - keep your cooling tower in top shape, it's essential to flush out dirt and debris from the cold-water basin. This simple maintenance task can help prevent clogs, reduce equipment damage, and keep your cooling tower running efficiently. and prevent dirt accumulation.
6. Adjust the bleed rate according to local regulations -Adjust the bleed rate according to local water quality and evaporation rate regulations to prevent the accumulation of solids in recirculating water.
7. Check the oil level and shaft alignment for gear drive systems -Routinely check the oil level and shaft alignment for gear drive systems, following the manufacturer's recommendations to ensure reliable service and prevent premature wear.
8. Inspect the makeup water supply - Regularly inspect the makeup water supply to ensure that the predetermined water level is maintained, conserving water and reducing air entrainment.

Conclusion:

It is well known fact that the Efficiency of any Organization depends on the Production rate as efficiency is nothing but the ratio of output quantity to the Input quantity. From the above study it is concluded that the due to the decrease in the temperature of cooling water, efficiency of evaporator and dryer has been increased. Also due to the decrease in the temperature of cooling water, the steam consumption by evaporator and dryer section has been decreased by large amount. Due to the decrease in steam consumption large amount of money has been saved.