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THE SIGNIFICANCE OF PROPER COOLING TOWER WATER TREATMENT: A CASE STUDY

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Abstract:

This paper presents the result of a study of the effect of cooling tower system in terms of performance and cost of maintenance. The study was conducted in a two-storey shopping complex building. Observation on site was held to obtain data on full load amp (FLA) and chilled water temperature (CWT) beforeand after servicing cooling tower unit. Energy of cooling tower were evaluated by analysis of FLA and CWT in percentage value. The condition on the system and component were also observed to differentiate the condition before and after treatment. The result obtained showed that cooling system performance after the treatment was increased.

Keywords:

Heat Exchange, Energy Management, Maintenance Cost, Cooling Coil

Introduction

Heat rejection devices to transfer heat to the atmosphere through the cooling water stream are Cooling towers. Heating, ventilating and air conditioning system (HVAC), oil refineries, thermal power station, nuclear power station and other chemical plants applied this cooling water circulating. There was a several types cooling tower commonly used in the central air conditioning plant or in process cooling. There is natural draft, side flow type, counter flow

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type and cross flow type cooling tower. A cooling tower may account for three quarters or more of the water used in a commercial building. Evaporation takes away pure water, leaving behind the minerals. This requires constant dumping and replenishing of water to keep the system mineral content at an acceptable level to prevent scaling and other consequences.

The lack of cooling tower water treatment can result in decreased efficiency, increased maintenance costs, and potential health hazards. It is important to employ effective water treatment measures to mitigate these issues and ensure the continued functionality of cooling systems (Pérez-Lombard et al., 2008).

Onsite investigations were held due to the increase in power usage of the HVAC system in the building. From the observation the result present in this paper explaining the potential effect and the consequences if no application of cooling tower water treatment for the central air conditioning plant. Basic operation of cooling tower process and general principles of chemical water treatment for cooling tower also explained in this study. This study also provides all the information of an important aspect containing process in cooling tower, objective of general principles of chemical water treatment, problem in cooling water system and the need for chemical treatment for cooling water circuit (Khan et al., 2003).

This study was conducted in a double story shopping center office building with gross floor area 18,800 m^2. From monthly energy observation report there is an increment of energy consumption in the building for the past three years. Energy use intensity (EUI) year 2019 increased for about 5.4% compared with EUI year 2012. Energy costs also significantly increase. There are also complaints from some tenants due to the uncomfortable situation because that their office temperatures could not achieve thermostat set points especially during midday. The complaint was issued to the management team.

The observation focused on cooling tower condition because according to Nyoman Suamir., (2018) managing cooling tower services is the simplest way to reduce energy consumption in the building.

Recommendations for optimization on the cooling tower parameters are also presented in this paper to improve the energy performance of the building toward energy conservation.

Cooling Tower Working Principle.

In water cooled air conditioning system, the heat was absorbed by the chilled water from the building which gave up its heat to the refrigerant in an evaporator of chiller. The refrigerant is then compressed and passed into the condenser and finally gives up heat to cooling tower water. The heat from cooling tower water is then released to the atmosphere through evaporation water.

Evaporation process will evaporate the heat through a moving stream of water where the process heat transfer to the atmosphere. The heat from the water stream transferred to the air stream raises the air temperature and its relative humidity to 100%, and this air is discharged to the atmosphere (Khan et al.,2003).

The heat rejection process from cooling tower water significantly achieves lower chilled water temperature compared to air cooled or dry heat rejection devices. Water used as a coolant

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because readily, abundant and inexpensive, easy to handle, can carry amount of heat does not readily decomposed and does not affect significantly within normally used temperature.

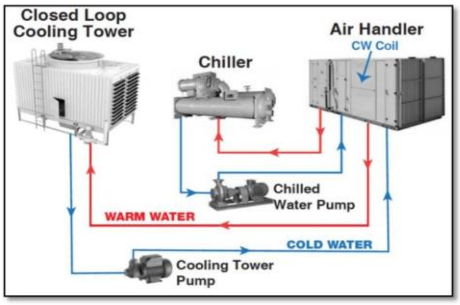

Figure-1 Process of The Heat Rejection In Cooling Tower.

Table 1: Cooling Tower Technical Specification

Parameters	Cooling Tower
Heat rejection capacity	500 TR
Running current	15.2 A
Air Flow rate	32.5(m^3s^{-1})
Voltage	380 (V)
Phase	3
Power Input	11.4(Hp)

TR = Tons Refrigeration, Hp = horsepower

Slime, corrosion, and scale will be formed due to use of water in this system. The existence will have a negative impact on the system. According to Project et al., (2022) lowered efficiency of heat exchanger, plugging of heat exchanger and an increment in servicing cost were the effect of slime, corrosion, and scale existence.

Methodology

This case study includes observation and data collection. Observation on cooling tower condition taking part before and after servicing process while data collection was focus on full load amp (FLA) and condenser water temperature which can be directly obtained from chiller panel in the plantroom. All the data presented in percentage value and compare it before and after the treatment while for cooling tower condition observation-based picture before and after cooling tower being service. The duration of the observation was taken during 5 days before treatment and 5 days after the treatment.

Results And Discussion

From cooling tower observation, all the condition before the treatment as in figure below.

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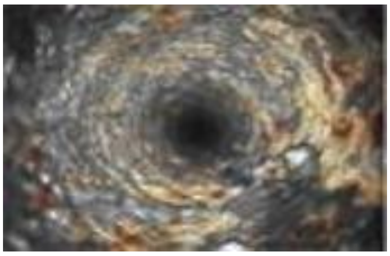

Figure 2: Scale In Inner Side Condenser Tubing

Crystallized mineral deposits accumulate on heat transfer surfaces. The temperature of the water inside the heat exchanger causes the mineral to come out of solution and form a thick layer around heat exchanger tubes. The insulating effect of the mineral deposits reduces effective heat transfer (Jouhara & Meskimmon, 2018)

Figure 3: Fouling And Scale On Condenser Tubing.

Organic and inorganic materials occurred on the heat transfer surfaces. The materials are suspended in cooling water in the form of charged particles. The charge of the metal components causes the particles to be attracted to heat exchanger surfaces (Cao et al., 2020). The buildup of deposits restricts water flow, reduces heat transfer, and provides a breeding area for micro biological organisms.

Figure 4 : Corrosion Effected the Condenser Unit

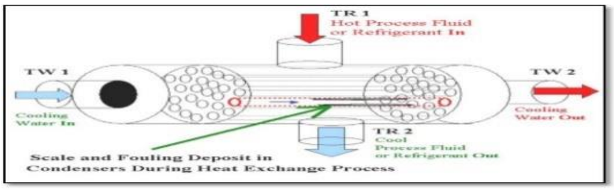

Figure 5: Problem Area in Condenser Unit

An electrochemical reaction that gradually dissolves or wears away metal. Corrosion is usually the result of air-water contact. The water becomes saturated with oxygen in the cooling tower and then moves into heat exchanger causing corrosion. Deposits of organic and inorganic away metal as mention by (Yang et al., 2018).

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Figure 6a: Algae on Cooling Tower Fins

Figure 6b: Algae on Cooling Tower Hot Basin Micro Biological Attack

Corrosion and fouling caused by the presence of microorganisms in the air and make-up water. These microorganisms include algae, bacteria, and fungi. By doing the cleaning and servicing process it will also prevent the presence of unwanted microorganisms, which will give a potential hazard to building air circulation (Rasta & Suamir, 2021).

From the analysis and observation, the consequence when neglecting cooling tower treatment to the building management as below.

Increase Equipment Replacement Cost.

Equipment failure can be catastrophic and lead to downtime, injuries, and costly equipment replacement. Chiller operation will decrease due to presence of rust and sludge on chiller piping system, harmful acid that occur due to this problem may cause chiller failure. Tube failure often caused by freeze damage, internal pitting, erosion, and metal deposit can result in expensive and time-consuming repair. High repair cost also includes condenser re-tubing and replace equipment premature failure.

Premature Equipment Failure such shorten life and reliability of compressor motor, water pumpmotor due to system need to work harder because of rust build up in the heat exchanger tubes and pipeworks. Shorten life of electrical component due to overload, overheated causing damage to power wiring and components. All the stated such equipment failure would be a factor that caused increasingin equipment replacement costs (Wang et al., 2018).

Increase Energy And Operating

Leaks in the refrigerant system due to erosion and freeze attack can reduce refrigerant charge and limit the chiller heat transfer capacity thus increasing head and energy use that may increase the building operation cost (Geng et al., 2019). Operating cost typically represents the largest expenditure over the useful life of a mechanical system, 50% of overall building electrical consumption was from HVAC system. Full load energy can be saved 1.5% if the evaporator temperature can be reduced by 1%. Similarly, to condenser inlet water temperature, energy saving at full load is about 1.5% for every1ºF the entering condenser water temperature (ECWT) is reduced.

Increasing energy consumption by chiller if the fouling factors rises from its standard value of 0.00025 to 0.003. The accumulation of scale in chiller condenser tubes can cause an increase in thermal resistance in the heat exchanger, leading to an increase in energy consumption. It was found that 1mm of scale can cause 52% reduction in the heat transfer efficiency of condenser. It was found that 0.006 inches of fouling requires a 45% increase in the heat transfer area. Fouling can cause a decrease in the heat transfer coefficient, which reduces the thermal efficiency of the heat exchanger and changes the pressure drop characteristics. Nyoman Suamir et al., (2018), it was found that microbiological film deposited in count four

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times the heat retardation effect of scale. Microbiological film has an even greater heat transfer retardation effect on that scale. The compressor consumed more energy to overcome the composite for the loss of heat transfer efficiency caused by scale and fouling in the condenser tube. Energy consumption by chiller will be increase for 20% if 0.6mm of scale occurred in the condenser Nisa & Kuan, (2021). damage to power wiring and components. All the stated such equipment failure would be a factor that caused increasingin equipment replacement costs (Wang et al., 2018).

Increase Maintenance Cost.

Condenser tubes need to be clean, if the temperature difference between the leaving condenser and therefrigerant is more than 4ºF greater than the manufacturer recommended temperature differential. By neglecting the routine chemical treatment in the chiller system, cleaning using manual cleaning method that employs caustic abrasive cleaners must be done regularly (Sanz-Calcedo, 2019). Brushing process can only remove dirt and sludge in the tube, but to remove scale it is more effective to do an acid wash by circulating the acid through the tube.

The untreated cooling tower water causes uncontrolled algae growth, contamination (rust, oils, grease, dirt, grime etc.) and existence variety of microorganism. Regular physical cleaning of cooling tower and heat exchanger in extreme conditions need to be done more frequently compared to the system that applied with water treatment programmed as mention by (Jouhara & Yang, 2018).

It will contribute in high labor and cleaning costs. All these factors will increase the frequency of unscheduled maintenance service, unbudgeted costly equipment repair, and risk of catastrophic equipment failure. Yearly budgeted for Preventive Maintenance Programmed for this building was increased accordingly.

Costly Unscheduled Shutdown

This building is also facing unscheduled shutdown due to equipment breakdown. System deterioration such as motor suffers a burn out, tube failure identified as a potential costly unscheduled shut down. Certain parts may not be available locally. Bringing in the spare part from overseas through air freight is toocostly and cannot be avoided. Bringing back the system in a short period will involve high in intensive labor cost. The tenant was facing a hard time achieving the target sale. Overburdened costly equipment replacement in the effecting system cannot be avoided. Reduce Productivity – Decreased Efficiency(Saidur et al., 2010)

Failed air conditioning system will cause occupant's discomfort, inconvenience that may reduce of their productivity. The better room temperature results from a good and efficient chillerplant. Often failures of air conditioning plant can cause the greatest problem that may totally affect all the tenants in this building.

Without the proactive water treatment planned, can lead to untimely equipment upset, drop in efficiency and less reliability in equipment life. Equipment energy efficiency is mandatory to make major difference in product profitability, especially in application that frequently operate twenty fours every day(Soliman et al., 2022).

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Cooling Tower Servicing Work

To overcome all the issues that occurred, servicing work was conducted to service at heat exchanger and cooling tower. Figure 7 and 8 below shows tubing cleaning in heat exchanger.

Figure 7: Tubing Cleaning

Figure8: Water Being Flush Out During Tubing Cleaning Works

Figure 9: Cleaning Cooling Tower Fins

Figure 10: Cleaning Cooling Tower Hot Basin

Figure 11 and 12 show the significant effect to the Full Load Amp demand and Entering Condenser Water Temperature after servicing heat exchanger and cooling tower cleaning was done. Full load amp (FLA) is the maximum current draw that a motor or equipment can take when running at full capacity. The current usage of a cooling tower is directly related to its energy consumption because the motor that powers the fan or pump consumes electricity and generates heat while running.Therefore, the higher the FLA of the motor, the higher the energy consumption of the cooling tower.

Figure 11 : Full load Amp

Figure 12: Entering Condenser Temperature (ECWT)

Furthermore, the current usage of a cooling tower can vary depending on the load it is currently handling. When the cooling demand is low, the motor may draw less current and consume less

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electricity. Conversely, when the demand is high, the motor may draw more current and consume more electricity. ECWT also showed an improvement after the servicing process where there is a decreasing entering temperature value as in Figure 12. Therefore, understanding the FLA and current usage of a cooling tower can help to optimize its energy efficiency and reduce operating costs (Oliveira & Ukil, 2019).

Conclusion and Discussion

From this case study it can be concluded that there is a compulsory planned, proactive maintenance and water treatment program in chiller plant, to improve chiller reliability and increase equipment life. Well organized schedule for routine checku p for cooling tower can reduce the frequency of unscheduled service calls and minimize the risk of catastrophic equipment failure and the associated potential for downtime, injuries, and unbudgeted, costly equipment repair and replacement. All of thiswill overcome the high energy consumption and it will increase the effectiveness of cooling tower system as heat rejection device.

Acknowledgement

This study is intended as a maintenance reference where it is very important in giving awareness about maintenance management especially in maintenaning the HVAC system. During the study, various parties such as industry, shopping complex and institutions such as Kuching Sarawak Polytechnic have given a lot cooperation, especially the Maintenance Department of Kuching Sarawak Polytechnic.

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