Thermodynamic Investigations of water cooler Chiller Plant of an air-conditioning System

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Abstract— **As we know, Chiller plant is a mechanical system which can be used for heat removal of refrigerant in a central air-conditioning system. In this pilot study Chiller plant (600 TR Capacity) of AUR located behind SRC building was investigated. Cooling Water (Secondary Refrigerant) of Central air conditioning system is cooled in this chiller plant using R-134a (1,1,1,2-Tetrafluoroethane) refrigerant (Primary Refrigerant. On investigation of the chiller plant, some problems (Like no use of damper) were identified. If we can properly address areas of concern, Performance of system may improve.**

Index Terms— **Chiller plant, water, refrigeration, Performance.**

I. INTRODUCTION

Chiller plant is a set of assemblies which comprises of an overall package including water chiller, air-conditioning system, and air/water cooled condenser. It means, a chiller, condenser, piping and compressor are acting as a single unit. Chiller plant may vary in size and capacity from small capacity reciprocating compressor units with water/air cooled condensers up to large capacity units having screw/ Centrifugal compressors. Though the package of a chiller plant is more complex, the basic components required for mechanical refrigeration are the compressor, evaporator, condenser and thermostatic expansion valve. These so called chillers are largely used for air conditioning, which includes comfort and controlled process applications. Typical comfort air conditioning applications are in larger commercial or domestic buildings where the capacities are bigger such as Universities, Hospital, Shopping Complexes, corporate offices, Schools etc.,

II. LITERRATURE SURVEY

In this research, the details of literature survey are as follows:

2.1 Mr. Jayesh S Arya & Dr. Neeraj K. Chavda (2014): in this paper it has been discussed that the actual and theoretical work done in the configuration scroll compressor and shell and tube heat evaporator is more than the configuration scroll compressor and plate heat evaporator. Moreover the actual cop for the configuration scroll compressor and plate heat evaporator is less than the configuration scroll compressor and shell and tube evaporator..

2.2 Xiupeng Wei etal (2014): In this research, A data-driven approach is utilized to model a chiller plant that has four chillers, four cooling towers, and two chilled water storage tanks. The chillers have varying energy efficiency. Since the chiller plant model derived from data-driven approach is nonlinear and non-convex, it is not practical to solve it by using the traditional gradient-based optimization algorithm.

2.3 P_erez-Lombard L, etal (2008): Researcher has highlighted the fact that a chiller plant normally consists of chillers, cooling towers, pumps and chilled water storage tanks. It is frequently used to air conditioning large office buildings or campuses with multiple buildings

2.4 Technical report Building energy data book. U. S. Department of Energy (2009) According to this report , More than 40% of the total electricity in a building is consumed by the chiller system. Thus effective energy management of chiller plants is becoming important to save energy consumption and reduce environmental impact.

2.5 Gregor p henze (2013) : This article describes a field study conducted on two university campuses in Massachusetts and Colorado during the cooling season of 2011. The purpose of this experimental study was to alleviate AT degradation problems on both campuses through the use of intelligent pressure-independent control valves, and to quantify the improvements achieved.

2.6 Madhur behl, (2012): This paper presents a green scheduling approach with chilling plants to reduce their peak power demands. A green scheduling approach means the use of thermal energy storage with VCRS, this thermal energy storage stores the energy in peak hours and uses that power in the time of need.

2.7 Troung Nghiem etal (2011) This research focus on Heating, cooling and air quality control systems within buildings and datacenters operate independently of each other and frequently result in temporally correlated energy demand surges. As peak power prices are 200-400 times that of the nominal rate, this uncoordinated activity is both expensive and operationally inefficient.

2. 8 Yung-Chung Chang (2006) This paper proposes a method for using dynamic programming to solve the optimal chiller sequencing problem and to eliminate the deficiencies of conventional methods. The coefficient of performance of the chiller is adopted as the objective function because it is concave. The Lagrangian method determines the optimal chiller loading in each feasible state. The potential performance of the proposed method is examined with reference to three example systems.

2.9 Yudong Ma etal (2009) has conducted a A preliminary study on the control of thermal energy storage in building cooling systems. We focus on buildings equipped with a water tank used for actively storing cold water produced by a series of chillers. Typically the chillers are operated each night to recharge the storage tank in order to meet the buildings demand on the following day

2.10 Nicola Ceriani etal (2013): This paper is concerned with optimal energy management of micro-grids. The goal is to show that the problem of minimizing the operating costs of

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a micro-grid by coordinating and scheduling its components can be formulated as a constrained optimal control problem for a stochastic hybrid system. A simple case study of a building cooling system with two chillers serving a cooling load is presented to this purpose.

III. EXPERIMENTAL SET UP

Chiller plant of Amity University Jaipur was investigated. Details of investigations are given below:

- Number of chillers in the plant – 03.
- Capacity of each chiller - 600 TR.
- Type of compressor **– centrifugal** type.
- Specifications of compressor used **carrier** chiller -

✓ Test pressure - 1407 kpa.
✓ Maximum working pressure - 1276 kpa.
✓ Volts AC/PH/Hz – 415/3/50 and 400/3/50 (carrier 1 and 2).
✓ Refrigerant used – **R134**.
✓ Warranty - 7 years.

- Types of Refrigerant used in **Trane** chiller -

✓ Liquid nitrogen.
✓ Di-chlorofluoroethane.
✓ HCFC – 123.

- **Current** required for the operation of the whole plant – 2000 Amp.
- **Power** of pump (condenser line) – 75 HP.
- Types of **valve** used -

✓ Butterfly valve
✓ Non-return valve.
✓ 2 port valve.

- **Amity Business School** - air cooled system (R22).
- **Amity School of Engineering & Technology** – water cooled system (R134).
- No coating on compressor.
- **Insulation layer** of chiller consist of 3 sub layers -

✓ Thermocol.
✓ Plastic.
✓ Cemented.

- Moisture is inversely proportional to efficiency.
- Temperature is directly proportional to efficiency.
- **Losses are high** in air cooled system as compared to water cooled system.
- **Inside the chiller –**
- 600 copper tube with an approx. diameter equal to our figure.
- Water flow through pipes.
- **Material** of pipe used - mild steel.
- Type of pipes used (on the basis of colour).

✓ **Green** colour pipe (D= 3ft) – cooling tower to chiller.
✓ **Blue** colour pipe (D= 2ft) – chiller to buildings.

- Water of condenser line is changed after every 7 to 10 days.
- Duct dimensions-

✓ Length - 8ft , Width - 4ft (duct sheets).
✓ Area of duct – 6 inch X 30 inch.
✓ Diameter of pipe taking water from chiller plant to block – 24 inch.
✓ Diameter of pipe taking water from cooling tower to chiller – 30 inch.

- Each floor of ASET consists of **13 AHU**. For each room 1 AHU is installed.
- If 2 motors are used for operating AHU, quantity of air flow = 3200 cubic feet per min
- (CFM) & 6 grills are use in ducts ends.
- For 2 motors, if volumetric flow is 2200 CFM & 4 grills are use in ducts ends.
- If only 1 motor is used to operate AHU volume of air flow to 1600 CFM & 3 grills are use in ducts ends.
- Each AHU consist of 50 copper tube through which chilled water flows. Air comes in contact with this pipes and hence becomes cool.
- **Condenser** temperature 80-82°C.
- **Room** temperature provided 20-22°C.
- ABS Air Handling Unit capacity is 11 CFM.
- Diameter of pipe used to take water to pump or from pump 10 inch.
- **Student Resource Centre's ground floor** is air cooled while remaining are water cooled.

IV. FINDINGS OF RESEARCH

Main findings of this research are Problems occurred in a chiller plant due to:-

1. Not using a "Damper"

Basically, a damper is used to cut-off the cooling/heating of a room as per one's need. However, no damper is used in our AUR-chiller plant which in turn does not allow to cut off the air conditioning supply of an unused room in the building. Also, having no damper in the system leads to the unwanted temperatures and thus, desirable efficiency and human comfort is not achieved.

2. Not using a "Sound attenuator"

One of the most common problems in any machinery is abnormal sound coming from some of its parts. This may be due to trouble with mechanical components inside the compressor. Hence, there is a requirement of a sound attenuator in the chiller plant to eliminate the irritating sound.

3. **Compressor is running continuously**

The function of compressor in a refrigeration system is to act as a pump to circulate the refrigerant in the cooling circuit. To maintain the cooling temperature in the rooms, the compressor is running continuously.

4. **Trouble Maintaining Temperatures**

You may find that the refrigerated space within your commercial refrigeration equipment is actually not cold/hot enough. In other words, the temperature cannot be regulated according to the requirement of the user.

5. **Inadequate Maintenance**

If you allow filters and air conditioning coils to become dirty, the air conditioner will not work properly, and the compressor or fans are likely to fail prematurely**.**

V. CONCLUSION

On the basis of data collected, it can be concluded that performance of water cooled chiller plant is much better than that of air-cooled plant. This is because of the fact that water as a cooling medium absorbs latent heat of vaporization, while air being in gaseous phase does not change its phase on absorption of heat. So, heat absorption capacity of water is much higher. Moreover, Water is changed in **every 4-5 months**, however if hardness increases (Hardness of water should be measured regularly), water must be changed in 15 days.

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