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Performance Analysis of Chiller System

Prof. Nitesh kumar [1], Mohit Lilhore[2], Neeraj Chouhan[3],Anuj Nare[4]

[1]*Professor, Dept.of Mechanical Engineering , Shri Balaji Institute Of Technology & Management,Betul ,Madhya Pradesh ,India*

2,3,4*Student , Dept.of Mechanical Engineering , Shri Balaji Institute Of Technology & Management,Betul ,Madhya Pradesh ,India*

Abstract
The objective of this research is to measure one unit chiller witha cooling capacity of 2,813 kW used for an office building. Themeasuring instruments are installed on the pumps, coolingtower and chiller. For calculation, the data of 6 days are collected. For improvement, adjustment flow is applied to the chilled water side on the secondary pump. Data recording is carried out for 6 days which include the chiller, chilled water pumps, condenser water pumps, and cooling tower. Overall COP system maximum is 4.4.

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I. INTRODUCTION

The objective of this paper is to reduce the energy consumptionof the building. The chiller that has a cooling capacity 2,183 kW is used for an office building in the central of Jakarta. The existing building has 9 floors, the total area around 32,181 m^2 and the air conditioning area around 26,000 m^2 which is covered by a chiller plant. Chiller plant work in primary and secondary pumps for distribution chilled water to Air handling unit (AHU). The system measured with power meters on all pumps, chiller and also a cooling tower. Flow meters installed on the chilled water supply to get the flow of the chilled water to calculate the cooling load. Then for the conclusion, the efficiency will get from the cooling capacity and the power used to estimate possibility saving.

An energy audit can be defined as an inspection or survey analysis of energy flows in a structure, in a process or in a system, intended to reduce the amount of energy input withoutnegatively affecting the outputs. It is the primary phase in proposing possibilities to diminish energy expense and carbon footprints and therefore, is a key point in decision making in the area of energy management. For an organization, an energy audit helps to understand, quantify, and analyze its energy utilization. It permits to detect where waste takes place, identifythe most critical points and discover opportunities where energy consumption can be reduced. [1]. The exact result of energy audits are usually quite complex to predict and the efforts that will be deployed and their cost- effectiveness are initially unknown. The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) has defined three progressives of an audit. Each audit level relies on the previous level. Obviously, the comprehensiveness of the site assessment, the amount of data collected and the detail provided in the final audit increase withthe audit complexity, but the potential of energy saving becomes higher [1]. Energy loss in any industrial process or plant is important, it is a foregone conclusion. But its economicand environmental impact is not to be taken lightly, thus explaining the growing need for industrial energy efficiency. Put simply, the level of energy efficiency a plant or process can achieve is inversely proportionate to the energy loss that occurs, the higher the loss the lower efficiency [2].

II. EXPERIMENTAL PROCEDURE

Instruments are installed on the chilled water side for temperature and flow meter. (The schematic is shownin figure 1).

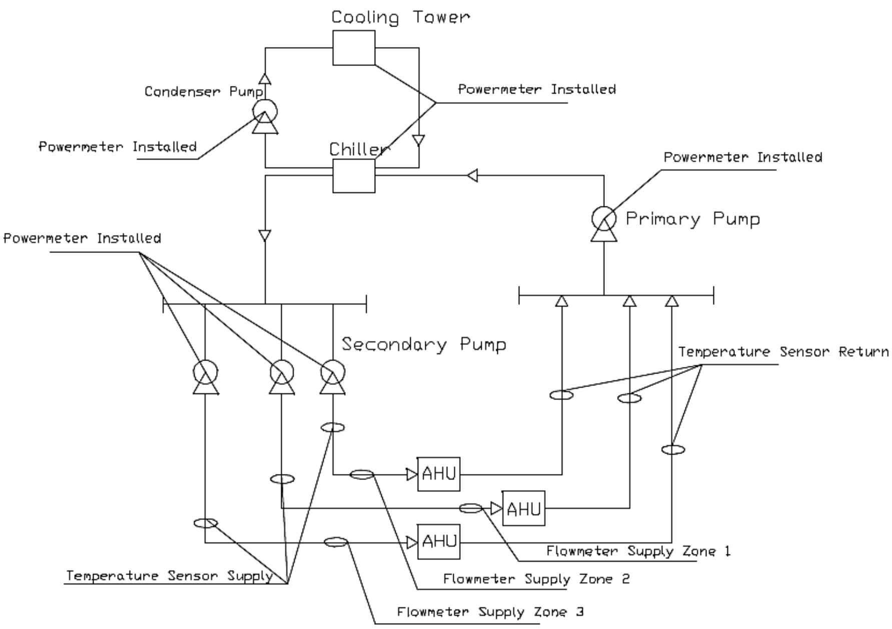

Figure 1. Schematic of the Instruments and the System

There are 3 zones that distribute for the building (2 brancheseach zone which is the supply and return of chilled water) shown in figure 2.

Figure 2. Chilled Water Pipe (Supply and Return)

Temperature sensors that use for reading the temperature on chilled water are a thermistor sensor (shown in figure 3).

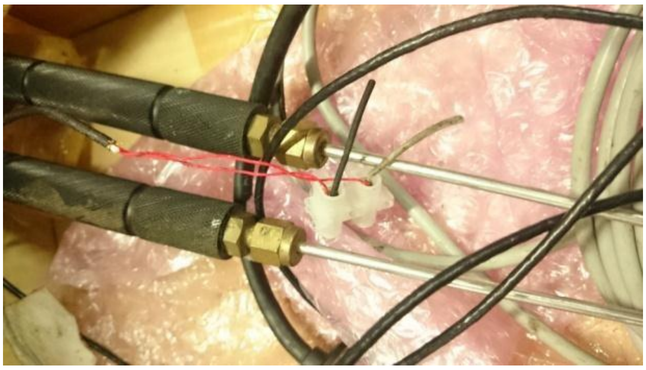

Figure 3. Thermistor Sensor (Temperature Sensor)

Flow meters that use for reading the water flow is an ultrasonic sensor. 1 set of flow meters are consist of 2 components that are transmitter and receiver and clamped onthe pipe to read the water flow (shown in figure 4).

Figure 4. Flow meter Ultrasonic (Transmitter and Receiver)placed on the Pipe

Power meters placed on every output pumps, chiller and cooling towers in panels (Figure 5), power meters will record the current of the pumps during operation. The data recorded every 1 minute in 24 hours. Every 2 days the file is downloaded from the logger to avoid some abnormal data. Ifthere is abnormal data, the instrument must be checked whether do the instrument shift on the normal position, or there is abnormal reading. If that happens all the abnormal instrument must be cross check 1 by 1. Data from the logger will be processed in the laptop (Figure 6).

Figure 5. Power meter (Black with Wire) is Clamped onElectricity Panel

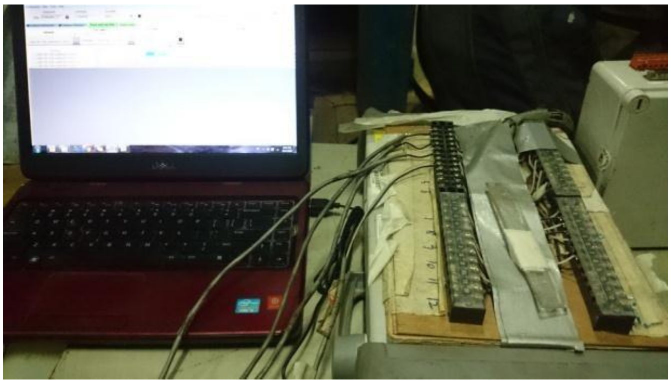

Figure 6. Logger Data (Right) and Laptop (Left)

From data collection, the cooling load is around 1,937 kW with 6 days of the data record from the instruments. 1-day data measure of the building efficiency in normal operationalcondition, then in the next day (5 days data) there is an adjustment to flow, to analyze the efficiency of the system include cooling tower, primary pump, secondary pump and also chiller.

The calculation for the Coefficient of Performance (COP) ofthe system :

$$COP = \frac{Cooling\ Load\ (kW)}{Power\ Input\ (kW)}$$

III. RESULT AND DISCUSSION

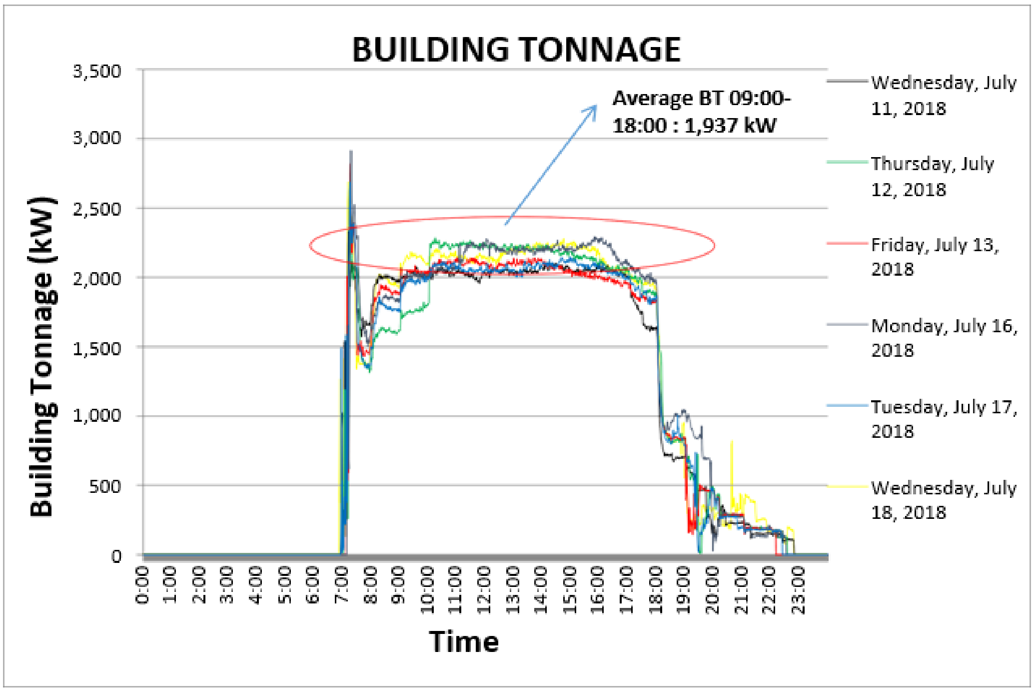

Figure 7 Building Tonnage Chart

Building tonnage chart as shown in Figure 7 represents the cooling load of the building that is 1,937 kW which the building onlyneeds to use 1 chiller that has cooling capacity 2,183 kW.

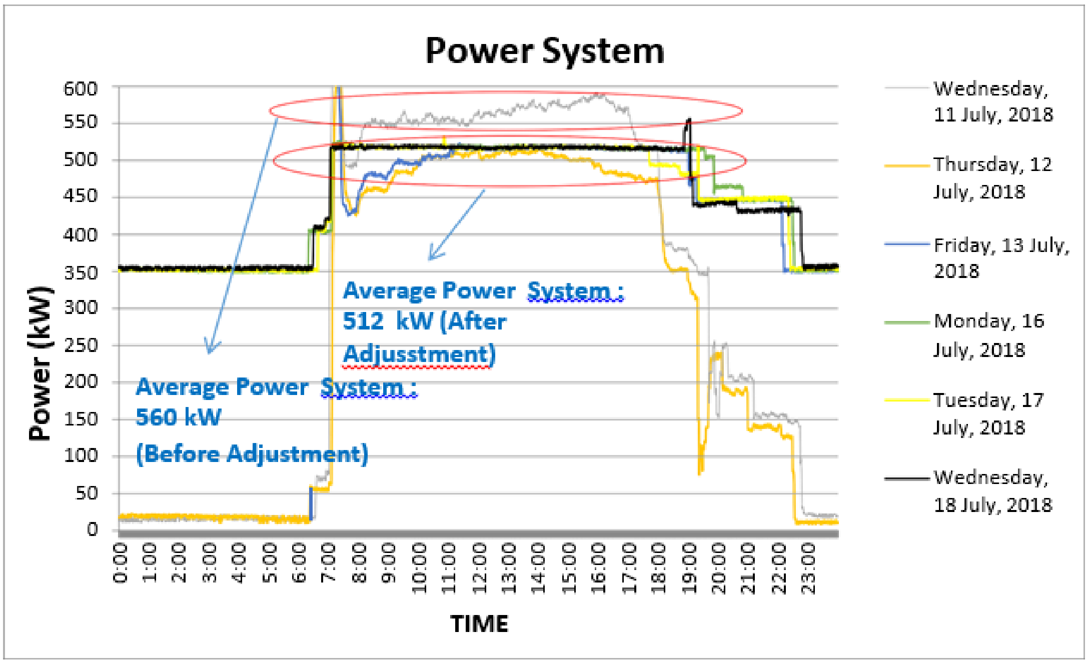

Figure 8. Power System Chart

The power system chart in Figure 8 represents the total power input for the chiller plant, including the power of chilled water pump (CHWP), condenser water pump (CWP), cooling tower, and chiller. Power recorded to the logger and gets the power configurationof the chiller plant. The average power system is shown above 560 kW for all equipment.

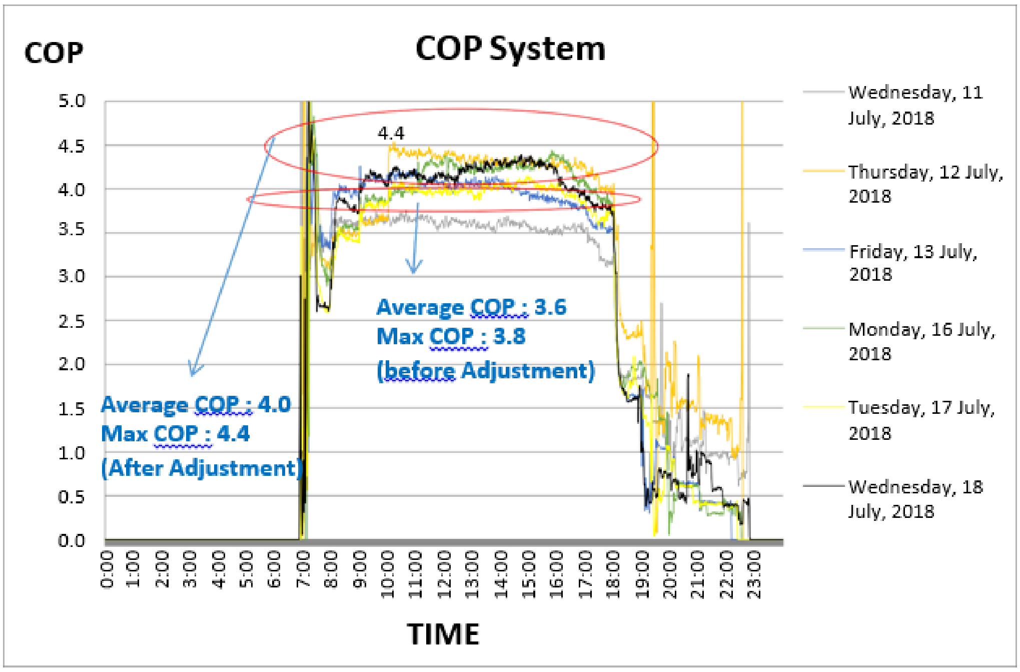

Figure 9. COP System Chart

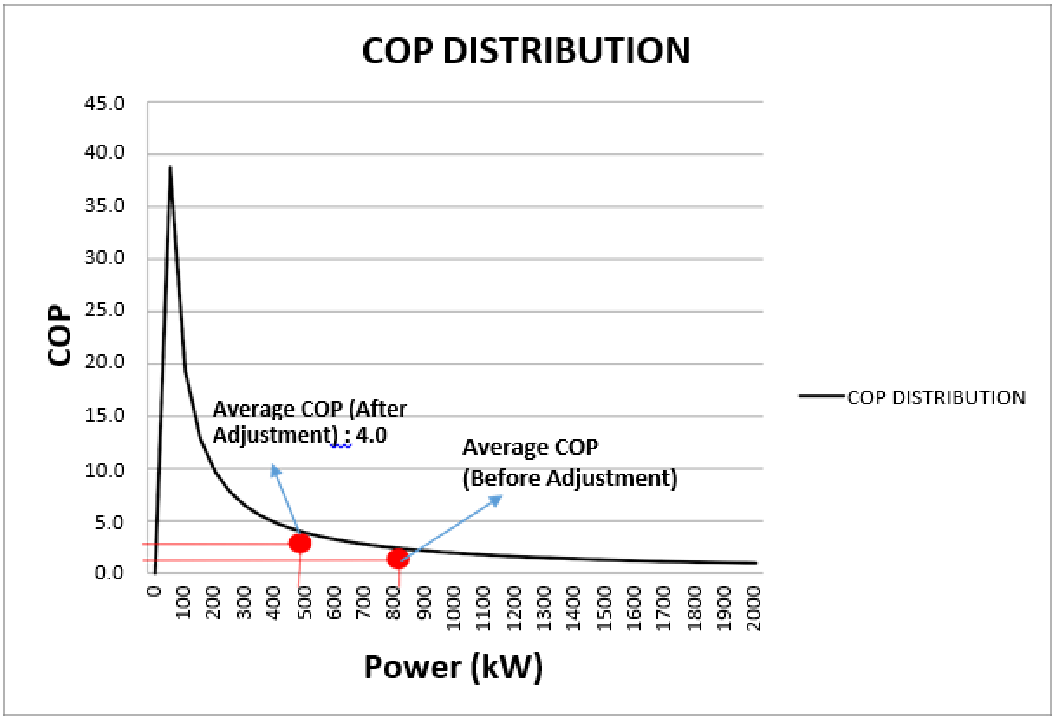

Figure 10. COP Distribution Chart

As an experimental result, table 1 represents a comparison about before and after adjustment of the chilled water flow to get animprovement of energy consumption.

Table 1. Experimental Result

	Average CoolingLoad kW	AveragePower kW	AverageCOP	% Improvementof Power	kWh Consumption 1 Year	Cost/Year USD 0.0839 USD/kWh	Saving/Year (USD)
Before	1,936.77	561.57	3.45	7.2%	1,819,493.39	152,685	11,066
After	1,936.77	520.87	3.72		1,687,623.57	141,619	

After adjustment to chilled water flow in zone 2, there is an increase of COP from 3.4 to 3.7 based on average measurement of cooling load and power as shown in figure 9. Figure 8 represent the power input which is reduced from 561kW to 520 kW on average. Power decreased by 7.2% becausethe flow is reduced and also the power input of the pumps. Todecrease the flow need to see the pressure of the longest Air handling unit (AHU) from the building whether it still has pressure or not. The pressure will indicate the chilled water isstill can distribute to the longest AHU. Small deltatemperature from the chilled water indicated the flow is to over, it makes heat transfer not effective or not in maximal condition. The flow reduces from 1,240 gpm to 1,130 gpm from average 1 day. The Maximum COP is 4.4. , and total energy produce for 1 day reached 4,687 kWh Total energy consumption before retrofit gets 5,054 kWh each day. Thereis an improvement of 7.2%. If the electrical cost 0.08 USD/kWh than it can get saving USD 11,066 / year.

IV. CONCLUSION

From adjustment flow in the chilled water side, there is an improvement in COP. If the flow is reduced, the powerconsumption is also reduced. Adjustment flow depends on thetemperature differences from the chilled water side. A small temperature difference represents an overflow. The building owner can therefore save money of about USD 11,066 / year.

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