

THE ENERGY SAVING PROCESSES FOR UTILITY SYSTEM IN TPS

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Abstract

There are more and more non-linear electronic equipments such as inverters using in facility nowadays. These non-linear electronic equipments let us achieve energy saving, but induce other electrical pollution to the whole power grid in contrast. How to take the advantages from these energy-saving equipments without electric pollutions should be well considered at the first step of the utility operation in TPS (Taiwan Photon Source). Meanwhile, for there will be lots of chance that TLS (Taiwan Light Source) and TPS will be operated at the same time, the electrical power consumption will increase with no doubt. Under the circumstances of limited budget, some energy saving processes for utility must be applied. According to the historical data, the utility consumes the majority of power consumption. Even a small portion of usage saved will be a respectable amount. Thanks to the connection pipe between two utility buildings, the realization of the energy saving processes at the first phase of TPS project becomes much easier.

INTRODUCTION

The accelerator is a sophisticated facility and sensitive to environmental changes. According to the research by J. C. Chang et al., the supplied air temperature and cooling water temperature are the critical factors to affect the beam orbit [1]. Once the temperature fluctuations of cooling water and air exceed 1 °C and 0.2 °C respectively, the stability of beam orbit will become worse. For this reason, a lot of efforts had been made to realize precise temperature control. On the other hand, precise temperature control prevents unnecessary energy lost. The later reason is getting more and more important when it comes to energy conservation. For air conditions, Z. D. Tsai et al. have made experiments applying the Run-Around Heat Recovery process to air handling unit [2]. From the results, the temperature fluctuation of outlet air could be minimized to ±0.05 °C, and the energy saving runs up to 30%. In this article, the benefit of connection pipe between chillers in TLS and TPS will be introduced. The TLS and TPS chilled water systems hence support to each other, and the reduction of power consumption is the additional profit while new chillers operating. The coefficient of performance (COP) of overall chilled water system goes up too.

After four years of engineering constructions, the first light of TPS shines on December 31, 2014. It encouraged every member in NSRRC, at the same time, it also means more and more energy is required to operate both TLS

and TPS. Electrical power consumption is highly increased after the completion of civil construction of TPS. The number of contract power capacity has been increased from 3.5 MW in 2000 to 5.5 MW in 2015. The power bill in 2014 was also nearly three times more than in 2008. Figure 1 shows the monthly average fee in NSRRC from 2008 to 2014 [3]. Due to the rising bill and the limited budget, it is an urgent object to develop energy saving processes for utility group.

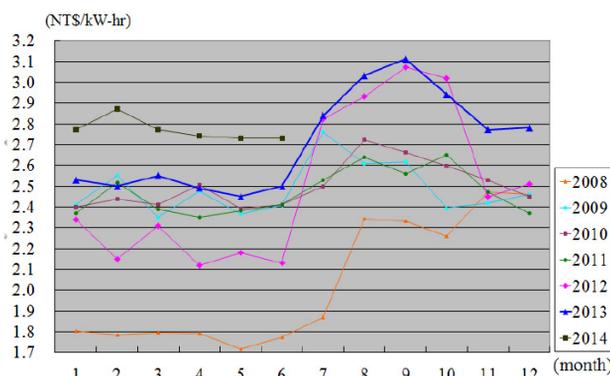


Figure 1: Monthly average fee from 2008 to 2014 in NSRRC.

RUN-AROUND HEAT RECOVERY PROCESS

Run-around heat recovery system is composed of ordinary air handling unit and two additional heat exchange coils. As shown in figure 2, these two additional heat exchange coils are used as pre-heating and pre-cooling coils separately.

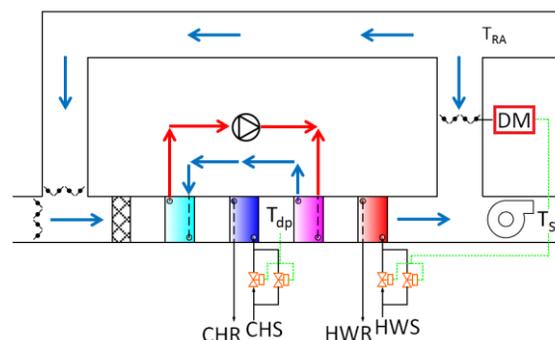


Figure 2: Control Diagram of High Precision Temperature Control System.

Counting from right side, the first coil is pre-cooling coil; the second one is cooling coil; the third and the

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fourth are pre-heating coil and heating coil in series. The flow rate of cooling coil is adjusted by two globe valves, which are controlled under the feedback of air temperature from pre-cooling coil. The two hot water valves work in the same principle.

For general air conditioning unit, the air temperature passing the first cooling coil is designed very low in order to condense water vapour. The humidity will be removed to achieve dehumidification, however, the air becomes very cold and need to be warm up to cosy temperature. It is double waste to power consumption. The pre-cooling coil cools down air a bit, and the exhaust heat of air will conduct to pre-heating coil. The pre-heating coil warms up the air before it passes through heating coil. The power consumption of the liquid circulating pump is the only cost during this process.

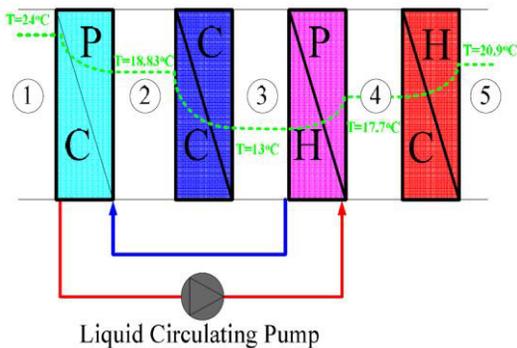


Figure 3: The Temperature Distribution of Run-Around Heat Recovery system.

The experiment result of temperature distribution of run-around heat recovery process is shown in Figure 3. Assuming the original air is 24 °C. After heat exchanging process in pre-cooling coil, the air cools down to 18.83 °C. The temperature difference is smaller compared with the condition without pre-cooling coil. Thermal energy between pre-cooling coil and pre-heating coil is exchangeable. It saves nearly 30% of energy in cool and heat exchangers separately, and the power consumption of circulating pump is only 3% of whole system. That is an impressive amount.

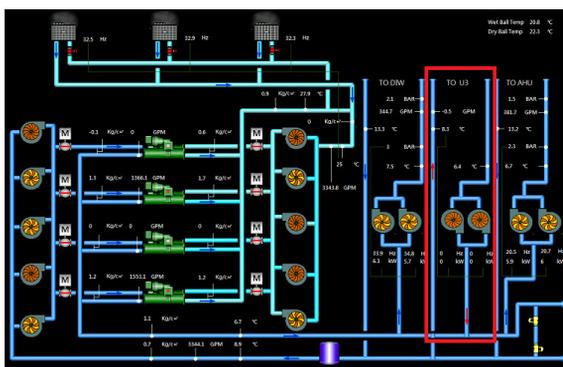


Figure 4: Chilled Water System in U2.

CONNECTION PIPE IN TLS AND TPS CHILLED WATER SYSTEM

Figure 4 is the graphical representation of chilled water system in the second utility building (U2) in NSRRC. The pumping set in red frame is connecting to the third utility building (U3). Chilled water system in U3 is newly set up. The COP values of these new chillers are undoubtedly larger than those in U2. According to the manuals, the COP of the 600 RT (Refrigeration Tons) chiller in U3 is 6.4 with 50% load. The COP is a parameter used to judge if the chiller saving energy or not.

From the historical data, the power consumption of U2 chillers reduced by 80 kW when the TLS shot down. Total amount of power consumption is 524 kW, including 320 kW from U2 chillers, 6 kW from cooling towers, 48 kW from chilled water pumps and 150 kW from cooling water pumps. In the same day, the connection pipes opened up and connection pumps operated to pump chilled water from U3 to U2. All chilled water was supplied by U3 chiller set.

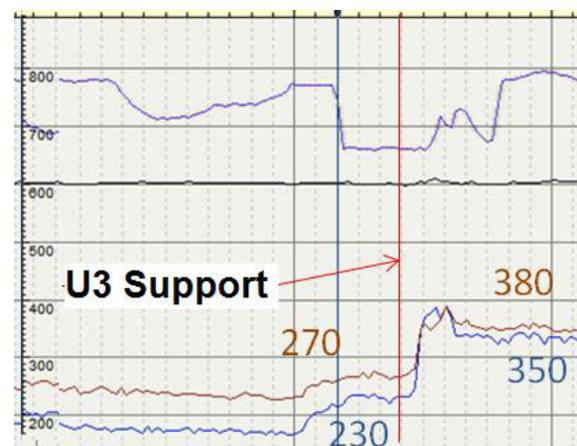


Figure 5: Power Consumption During U3 Chillers Supply Chilled Water.

The power increase while U3 supplied was shown as Figure 5. The brown and blue lines indicate the power consumption of two chillers in U3. The total amount of increase was 230 kW when all chilled water was supplied by U3 chillers. Comparing these two cases, 294 kW was saved in total energy consumption. U3 chillers operated with proper loadings in this case. Referring to Figure 6, the COP of U3 chillers increased from 4.9 to 5.8 and 4.8 to 5.78 separately.

The calculations of COP are as follows:

COP of Chiller A Before/After Switching:

$$320 \times 3.516/230 = 4.9$$

$$580 \times 3.516/350 = 5.8$$

COP of Chiller B Before/After Switching:

$$370 \times 3.516/270 = 4.8$$

$$625 \times 3.516/380 = 5.78$$

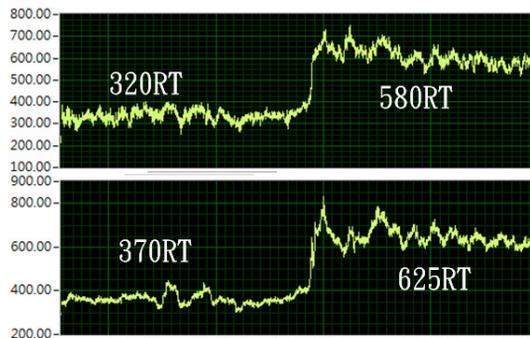


Figure 6: The Refrigerating Capacities of U3 Chillers.

CONCLUSION

In this article, we describe the energy saving processes for utility system in TPS. Due to the limited budget, every possible method must be tested. We introduce the “Run-Around Heat Recovery Process” which is applied in air conditioning system. The experiment result shows nearly 30% of energy saving in heat exchangers as long as add two pre-cooling and pre-heating exchange coils and one circulating pump.

The application of connection pipe between U2 and U3 increased the COP of U3 chillers. The COP of two U3 chillers rose up to about 5.8 separately. Total power consumption saving was 294 kW.

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