AIR CONDITIONING SYSTEM CONTROL STUDY AND IMPROVEMENT FOR TRANSIENT EVENTS IN THE TLS STORAGE RING

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Abstract

It has been studied and verified that thermal effect is one of the most critical mechanical factors affecting the beam stability. There are many accelerators have controlled the global air temperature variation in the storage ring tunnel within ±0.1°C during stable beam operation in the world. However, some transient events, such as unexpected beam loss or beam trip will clearly affect air temperature variation. Moreover, machine shutdown will change the air conditioning status radically. It will also take time to reach a stable air temperature after machine shutdown. This paper presents effects on the air temperature by those transient events and improvement schemes.

INTRODUCTION

It is known that thermal effect is one of the most critical mechanical factors affecting the beam stability. We had studied the utility effects on beam quality [1] to verify those effects on the stability of the electron beam orbit at Taiwan Light Source (TLS).

We also conducted a series of air conditioning system improvements of the storage ring. The air temperature variation had been controlled within ±0.1°C related to time. We also applied mini environmental control on the area of the elliptically polarizing undulator EPU. By the forced convection cooling, temporal air temperature variations was controlled within ±0.05 °C during over 40 hours' operation. [2] However, the temperature gradient and effects of transient events were still critical topics to be studied.

Therefore, numerical simulations were performed to analyse the flow field and temperature distribution of the experimental hall, the storage ring tunnel, and the core area of technical equipment. Nevertheless, it is difficult to set the transient boundary conditions of heat sources, such as cables, magnets, motors, vacuum chambers etc. We could only observe rough flow pattern and temperature gradient through numerical simulation. It still needs more experiments to verify the simulation results.

The air conditioning system of the TLS tunnel area had been improved by increasing cooling capacity and replaced old air handling units (AHUs) by power-saving and anti-vibration ones. In this study, we applied practical and effective air temperature control to cope with some transient events, such as unexpected beam loss or beam trip. The air conditioning system of TLS and the automated data acquisition system are also presented in this paper.

AIR CONDITIONING SYSTEM OF THE TLS TUNNEL AREA

There are two air handling units (AHUs) for the whole storage ring tunnel at TLS. Figure 1 shows the control system of the AHU. As shown in the figure, return air from the storage ring tunnel is mixed with outdoor air then flows through a chilled water heat exchanger, which is controlled by a chilled water control valve to control the mixed air temperature to 13 °C. Cooled air then flows through a hot water heat exchanger, which is also controlled by a hot water control valve to control the mixed air temperature to a fixed value between 17-20 °C, depending on atmospheric conditions.

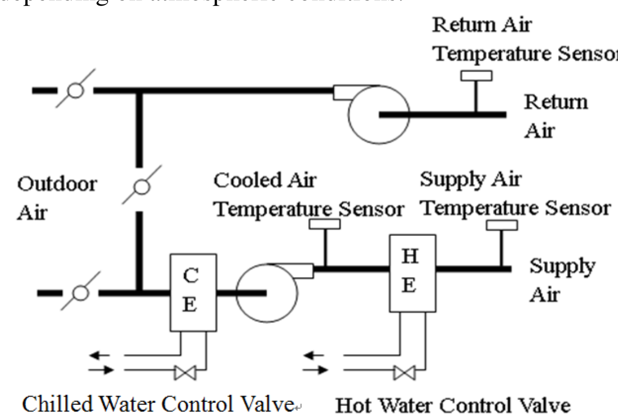


Figure 1: Control system of the AHU for TPS tunnel.

Two AHUs are located on the core area of the storage ring. We also paid attention on the vibration issue. Several anti-vibration techniques are applied on AHU and piping system to reduce vibration. Similar strategies were also implemented against noise. The specifications of the AHU are listed in Table 1.

Table 1: Specifications of AHU for the TLS Storage Ring

Air Flow (CFM)	Total		12860
	Outdoor Air		1286
Fan	Total Static Pressure (inch-WG)		3.5
	RPM		1962
	Blade Diameter (inch)		22×16
	Motor (HP)		20
Cooling Coil	Supplied Air Temp(°F)	DB	64.2
		WB	62.4
	Leaving Air Temp (°F)	DB	54.7
		WB	53.9
	Area (ft^2)		26.9
	Velocity (FPM)		479

The air temperature of the storage ring tunnel is controlled through four variable air valves (VAVs), labeled as R4A-R4D. Each VAV controls eight air inlets and two air outlets, as shown in Fig. 2. The openings of the valves for chilled and hot water are auto adjusted by the controller according to the temperature difference between the setting value and the actual inlet air temperature.

The storage ring tunnel is divided into six sections. There are six thermocouples distributed in each section for online monitoring.

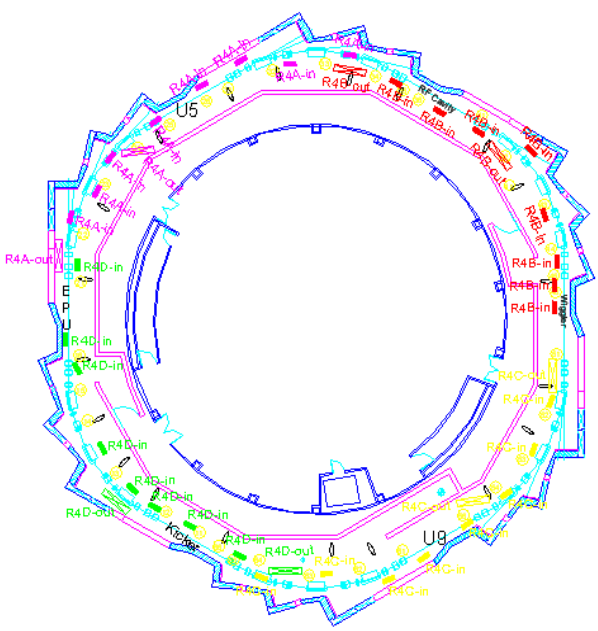


Figure 2: Air conditioning ventilation inlet and outlet distribution in the TLS storage ring tunnel.

AUTOMATED DATA ACQUISITION SYSTEM

We had also developed a utility archive system to on-line monitor thousands of utility parameters. Although each of the utility subsystem, such as the electrical power system, the cooling water system, the air conditioning system etc. is equipped with its specific monitoring and control system, the utility archive system effectively integrates all those subsystems. The utility archive system is an integrated software written by the LabView language. This archive system consists of a remote viewer level, a data service level, a data processing level, a control level and a device level. The remote viewer level is opened for all in house and outside users. The 'Archive Viewer' in the remote viewer level is software of viewing for the whole archive system. Archive Viewer was developed with a series of on-line data-view functions, including table view, graphic view, web view, trend view, and dynamic signal analysis (DSA) view. Fig. 3 is the network of the utility archive system for the utility system.

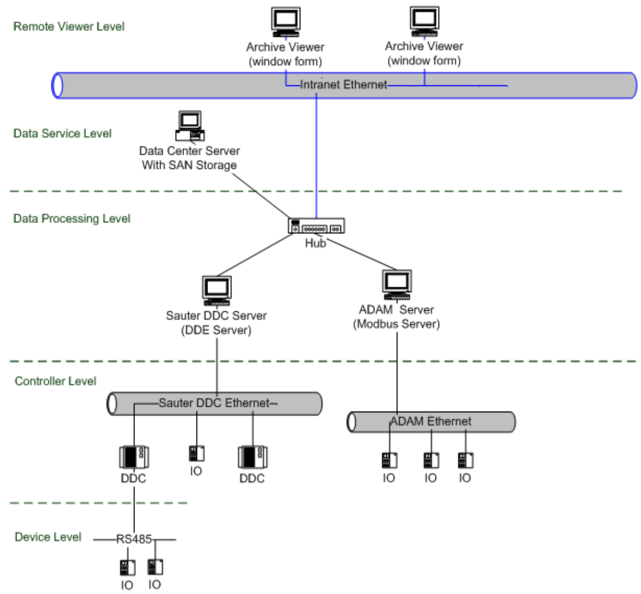
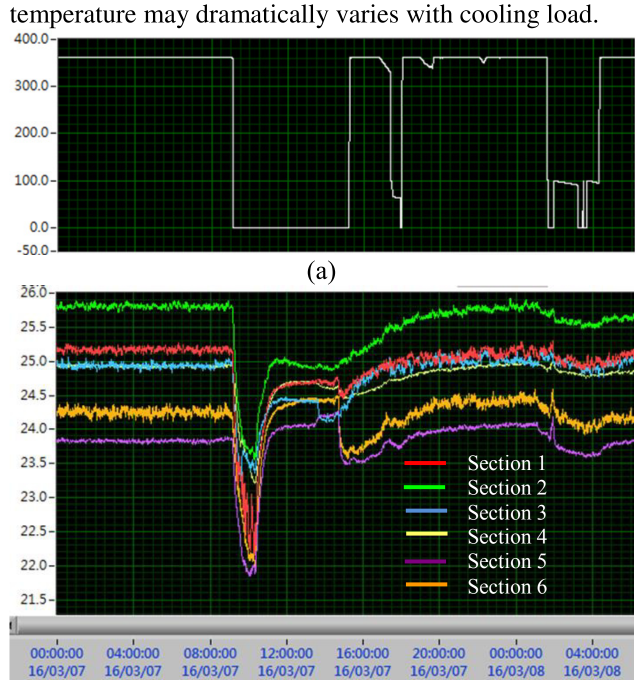


Figure 3: Network of the utility archive system.

TEMPERATURE CONTROL SCHEME FOR TRANSIENT EVENTS

In an air conditioning system, variation of cooling load will cause air temperature variation of cooling zone. In the normal operation of the TLS air conditioning system, we set the supplied air on a fixed temperature. Because the TLS is normally operated in top-up mode, beam current and cooling load is stable. Air temperature variation in the tunnel may be easily controlled within ± 0.1 ^{o}C. However, once the machine shutdown or trip, air temperature may dramatically varies with cooling load.



(a)

(b)

Figure 4: Beam current (a) and air temperature histories in 6 sections of TLS (b).

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Fig. 4 shows the beam current and air temperature histories in 6 sections. TLS is normally shutdown every Monday 9:00 am. It can be observed that the beam current was kept at 360 mA before 9:00 am March 7th 2016 in Fig. 4. Air temperature variation in 6 sections was also controlled within ±0.1 °C before 9:00 am March 7th. The machine was shutdown then restarted at 15:00 pm March 7th. Another beam loss happened at about 17:00. It is clear that the shutdown and unexpected beam loss strongly affected air temperature. This phenomenon happened again at another beam loss during 2:30 am to 4:20 am March 8th.

To improve our air temperature control scheme, we discussed with accelerator machine people. We at first thought that power of dipole magnets is the main cooling load in the air conditioning system. Therefore, we added status of power of dipole magnets into our air conditioning control system to cope with this air temperature variation problem caused by transient events. In the new control logic, we raised the set temperature of supplied air once the power of dipole magnets dropped to zero.

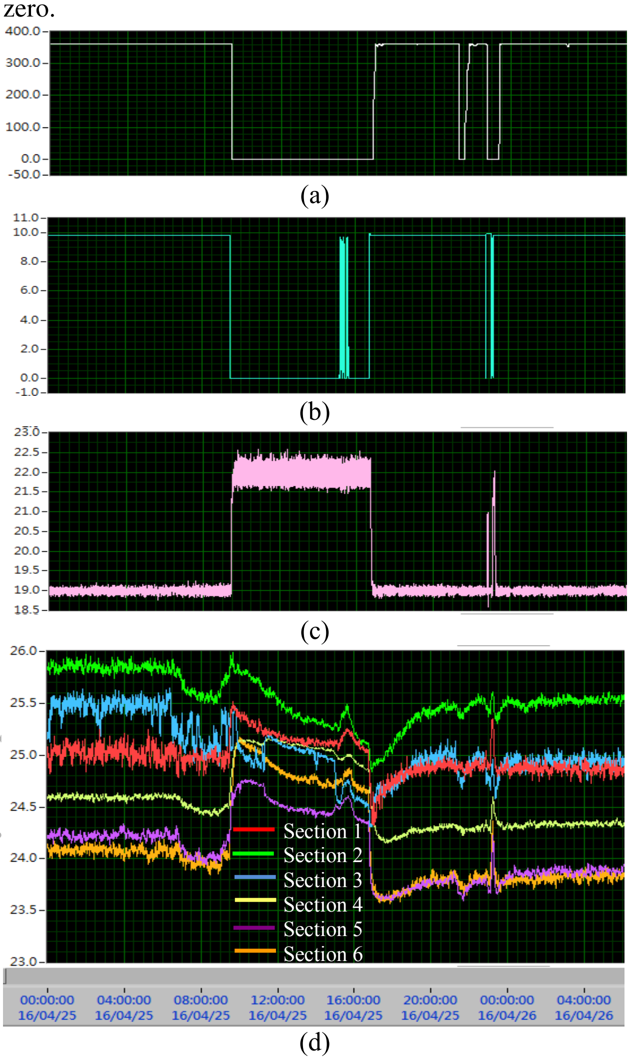

Figure 5: Histories of beam current (a), status of power of diploe magnets (b), supplied air temperature (c) and air temperature in 6 sections of TLS (d).

Fig. 5 shows histories of beam current (a), status of power of diploe magnets (b), supplied air temperature (c) and air temperature in 6 sections of TLS (d). In this figure, the beam current and the power of dipole magnets dropped to 0 due to machine shutdown at about 9:30 am 25th April. The supplied air temperature also rose from 19 °C to 22 °C simultaneously through control system. This scheme successfully raised air temperature in the tunnel. However, air temperature could not be kept stable during shutdown because machine people went in for maintenance. We also observed that power of dipole magnet was not the only cooling load in Fig. 5. Air temperatures in 6 sections of TLS dropped about 0.2-0.4 °C before machine was shutdown although supplied air was kept at 19 °C. This phenomenon indicated some equipment rather than power supply of dipole magnets shutdown and cooling load reduced accordingly. We will make more studies on those equipment and cooling load to control the air temperature better.

In Fig. 5 (a), there were two unexpected beam trips during 21:10 to 23:30 April 25th 2016. The power of dipole magnets only tripped on the second event. And the air conditioning system only responded on the second event to raise supplied air temperature, as shown in Fig. 5 (b) and (c). However, the first beam trip also induced air temperature sag, as shown in Fig. 5 (d).

We also found temperature rising of supplied air made different air temperature responses in the tunnel. It depends on whether the location of temperature sensor is near the air exit or not. Still, this air control scheme makes the average air temperature more stable.

CONCLUSION AND FUTURE WORKS

We have improved the air conditioning control scheme by raising the supplied air temperature once power of dipole magnets voltage drops to zero. It compensates decrease of cooling load and makes the average air temperature in the TLS tunnel more stable.

However, there are other cooling load rather than power of dipole magnets to be studied. We will also add beam status into our air conditioning control system to make more improvement on the response of some transient events.

ACKNOWLEDGEMENT

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