DESIGN OF THE UTILITY SYSTEM FOR THE 3 GeV TPS ELECTRON STORAGE RING

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Abstract

After 13-year operation of the Taiwan Light Source (TLS), National Synchrotron Radiation Research Center (NSRRC), had proposed to construct a new light source, Taiwan Photon Source (TPS) in the near future. TPS is preliminarily designed with 3.0 GeV in energy, 518.4m in circumference and 24 Double-Bend Achromat (DBA). This study designed the utility system, including the electrical power system, grounding system, de-ionized cooling water (DIW) system and air conditioning (A/C) system for the TPS. Special considerations are focused on the stability of the electrical power and grounding system and temperature control of the DIW and AC systems. The power and cooling loads had been estimated according to each subsystem of the accelerator. Layouts of main utility equipment and piping system had also been preliminarily designed.

INTRODUCTION

The TLS was constructed in 1993 of 1.3 GeV in energy, which was also the first third-generation synchrotron radiation facility in Asia. Although the performance of the TLS has been remarkably improved by means of some major projects, such as energy upgrade from 1.3 GeV to 1.5 GeV, installation of some insertion devices, cryogenics superconducting project and the top-up mode injection, TLS still gradually loses its advantage of competition due to its limitation straight sections and available space for new insertion devices. Accordingly, NSRRC had proposed to the government to construct a new synchrotron light source of TPS in 2005. To meet requirements of critical experiments and compete with mid-energy synchrotron accelerators around the world, TPS is designed with low emittance, high brightness, stability and reliability. Each subsystem of the TPS will apply the most advanced and reliable techniques to achieve this goal.

Utility system is one of the most critical subsystem affecting the beam quality and reliability. We had made many efforts on studying utility effects on beam quality and upgrading utility system since 1998 [1][2]. This study is aimed to present designs of three main utility subsystems, i.e., electrical power and grounding system, the cooling water system and the A/C system. The design and operational experiences of utility systems of TLS and other advanced synchrotron accelerators are valuable references for the utility design of the TPS.

LAYOUT OF THE UTILITY SYSTEM

To efficiently operate the existing TLS and construct the TPS under limit manpower, the TPS will be constructed next to the TLS. Main utility equipment of the TLS was installed in two existing utility buildings i.e., Utility Building I and Utility Building II. Main equipment of the cryogenics system was installed in the Utility Building II. There are two utility trenches respectively between the TLS ring and the Utility Building I and the TPS ring and the Utility Building II for the piping system and electrical power transmission. The schematic drawing of the TPS, TLS and two Utility Buildings is shown in Figure 1.

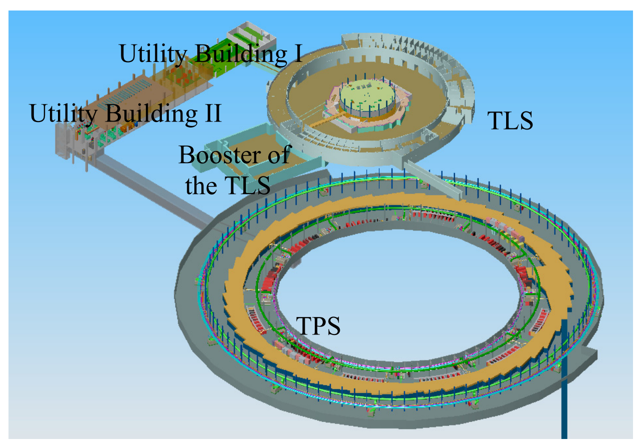

Figure 1: TPS, TLS and two Utility Buildings.

Figure 2 shows layout of the storage ring tunnel and technical trenches of the TPS. As shown in Figure 2, there are two underground trenches for the utility system and equipment of other subsystem of the TPS. Two main power substations and air handling units (AHU) are located in the inner trench (trench A), and the utility equipment for the experimental hall is located in the outer trench (trench B), as shown in Figure 2. The piping system in trench A mainly is for the storage ring tunnel. Trench A is divided into 12 sections; each section is equipped with two AHU for the storage-ring tunnel and the experimental hall. There are total 18 AHU installed in the Trench B for the experimental hall and laboratories.

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Wind ducts for the storage ring tunnel and the experimental hall are also shown in Figure 2.

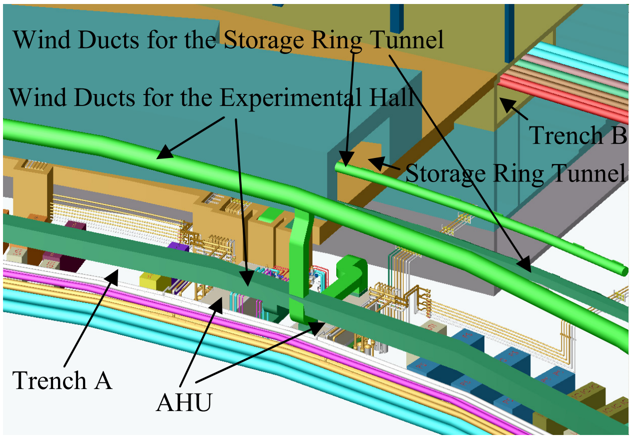

Figure 2: Layout of the storage ring tunnel and technical trenches of the TPS.

ELECTRICAL POWER AND GROUNDING SYSTEM

The electrical power capacity is evaluated according to power demand of each subsystem. The power load in the TPS storage ring can be basically divided into the magnet power supply system, the RF system, the HVAC and cooling water system, and other devices. The total TPS power demand of the storage ring is estimated to be 7580 kW, which is listed in Table 1. The power demand of the main utility equipment installed in the Utility Building II is estimated about 4.7 MW. The total power capacity of the TPS is estimated about 12.3 MW.

Table 1: Total power demand for the TPS storage ring

	power demand (kW)
magnet power-supply system	2500
RF system	2880
other precision devices	1200
Public-utility facilities	1000
total	7580

The electrical power system of TPS will be classified according to the power load. Basically, most power feeders are classified as the technical load or the conventional load. Some subsystem of the storage ring will be equipped with specific power feeder, such as the rf system, power supply system, vacuum system and processing load. The electric power SCADA (Supervisory Control And Data Acquisition) applied in the TLS [3] system will be installed according to the electrical power structure.

A commercial code CDEGS (current distribution for electromagnetic grounding and soil-structure analysis) is applied in design the grounding system of the TPS. The grounding resistance of the TPS is simulated about 0.2Ω. The grounding system will also be classified according to the power load to keep from the interference among systems.

COOLING WATER SYSTEM

According to the study of utility effects on the beam stability, thermal effect is the most critical mechanical factor affecting the beam stability [1][2]. Therefore, the design of the cooling water system of the TPS is important. In both the TLS and the TPS, the cooling water system includes de-ionized water (DIW), chilled water, cooling-tower water and hot water. All abovementioned cooling water subsystems are operated in close loops. The DIW system may be more divided into five subsystems, i.e., Cu DIW for magnets and power devices, AL DIW de-ionized water for vacuum chambers, RF DIW for the RF facility, booster DIW for booster devices and BL DIW for the beam line optical instruments. The specifications of abovementioned cooling water subsystems are listed in Table 2.

Table 2: Specifications of cooling water subsystems of the TPS

	Temperature	Pressure	Capacity
Cu DIW	25 ± 0.1 °C	7.5 ± 0.1 kg	800 GPM
AL DIW	25 ± 0.1 °C	7.5 ± 0.1 kg	250 GPM
RF DIW	25 ± 0.01 °C	7.5 ± 0.1 kg	300 GPM
Booster DIW	25 ± 0.1 °C	7.5 ± 0.1 kg	300 GPM
BL DIW	25 ± 0.1 °C	7.5 ± 0.1 kg	350 GPM
Cooling Tower	32 ± 0.5 °C	3.0 ± 0.2 kg	5500 RT
Chilled Water	7.0 ± 0.2 °C	3.5 ± 0.2 kg	4000 RT
Hot Water	50 ± 0.3 °C	2.5 ± 0.2 kg	1600 kW

The high precision water temperature control technique applied at the TLS [4] will also be used in the TPS. The temperature variation of DIW is controlled within ±0.01 °C. Figure 3 shows the high precision water temperature control system applied on the RF load. Because this technique occupies large space to install a water buffer tank, a new designed substitution of the water tank is under developed. The small typed high precision water temperature control system will be widely applied on local monitoring systems in the TPS.

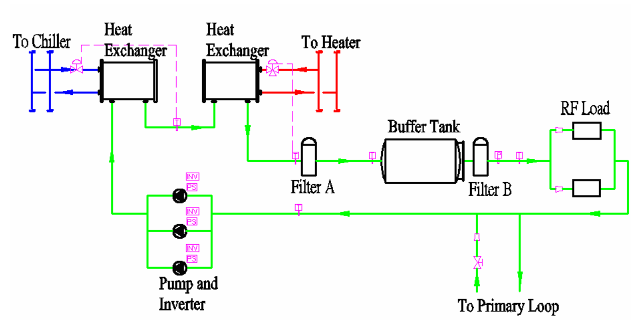

Figure 3: High precision water temperature control system.

Water treatment is another important issue in the cooling water system. The recycle system, RO system and deoxygenating system are main schemes to control DIW quality.

AIR CONDITIONING SYSTEM

A/C system is another critical system related to the thermal effect. The area of TPS may be estimated to be around 22,000 m^2. This is more than 4 times the area of the TLS. The total area of every floor and trench of the TPS is about 33,000 m^2. The cooling capacities of the chiller, the cooling tower and the AHU of the TPS are estimated about 4000RT, 5000RT and 3000RT, respectively.

The computational fluid dynamics (CFD) technique applied on the TLS [5][6] was also applied to simulate one of 24 sections of the TPS storage ring tunnel. All new designed magnets of the storage ring and booster, vacuum chambers, girders and supplied and return ducts are modelled in the simulation. Continuous openings of the supplied and return wind ducts are designed and simulated in the case. Boundary conditions are assumed according to designed data provided by each subsystem. Figure 4 and 5 respectively shows the simulated temperature and flow fields in the storage ring tunnel.

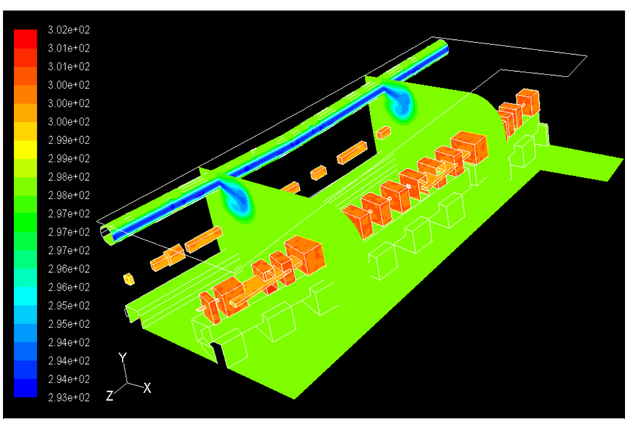

Figure 4: Simulated temperature field in the storage ring tunnel of the TPS.

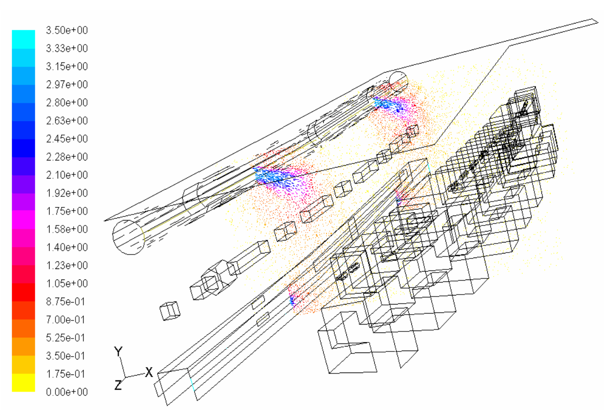

Figure 5: Simulated flow field in the storage ring tunnel of the TPS.

In both Figures 4 and 5, there are two cross sectional planes showing similar temperature distributions and flow fields because of the continuous wind duct opening. A zone of low temperature is clearly illustrates near the air exit on both cross sectional planes. A continuous band zone on the supply wind duct shows low temperature in blue color. The temperature of all magnets and vacuum chambers ranges about from 27 ^{o}C to 28 ^{o}C. Unsteady state cases are also simulated. The simulated results show the temporal air temperature variation is less than ± 0.1 ^{o}C.

CONCLUSION

The utility system layout of the TPS is designed and illustrated in 3D drawing. The electrical power demand and the cooling capacity of the DIW and A/C systems are estimated. Some utility schemes and experiences of the TLS, such as the power load and grounding classification, high precision DIW temperature control and CFD simulation are applied in the design of the utility system of the TPS.

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