UTILIRY DESIGN FOR THE 3 GeV TPS ELECTRON STORAGE RING

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Abstract

Having been running the Taiwan Light Source (TLS) for fourteen years since it's opening in 1993, National Synchrotron Radiation Research Center (NSRRC), Taiwan has been approved to build a photon source (TPS) last year. TPS is preliminarily designed with 3.0 GeV in energy, 518.4m in circumference and 24 Double-Bend Achromat (DBA). The utility system, including the electrical power, cooling water and air conditioning system of the TPS were designed to meet requirements of high reliability and stability. On the other hand, because the power consumption of the TPS is estimated about three times that of TLS, energy saving is another important issue. This paper therefore discusses utility design concepts and presents partial design results, including capacity requirements, equipment and piping layouts.

INTRODUCTION

It has been more than 15 years since the first beam stored in the storage ring at TLS. TLS is also known as the first third-generation synchrotron radiation facility in Asia. Although the reliability and stability of the light source have been upgraded for years, TLS has gradually lost its advantage of competition due to its limitation straight sections and available space for new IDs. In order to meet increasing demand for more state-of-the-art researches, the Board of NSRRC had decide to propose to construct the TPS to the government in 2004.

There are more than ten mid-energy synchrotron accelerators around the world in operation or under construction currently. In such a competitive circumstance, TPS is designed to achieve the targets of 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 subsystems affecting the beam quality and reliability. Some utility effects on beam quality and upgrading utility system had been studied in TLS since 1998 [1]. 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. However, it takes lots of discussion, debates, and modifications to design such a complex system. We had made the preliminary utility design for the TPS [2]. This study is aimed to present the latest designs of three main utility subsystems, i.e., electrical power and grounding system, the cooling water system and the air-conditioning (A/C) system.

LAYOUT OF THE UTILITY SYSTEM

To efficiently operate the existing TLS and construct the TPS efficiently, 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 Buildings I and II. Utility building III, especially for the TLS, is designed next to the existing two utility buildings. The power and main piping systems among three utility buildings will be connected for an efficient operation purpose. There are two utility trenches respectively connecting 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 three Utility Buildings is shown in Figure 1.

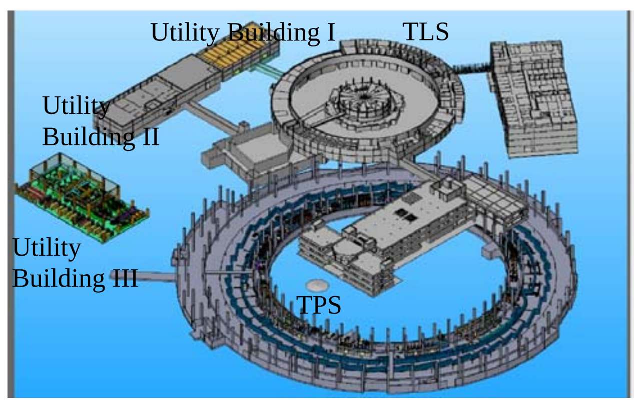

Figure 1: TPS, TLS and three Utility Buildings.

The TPS storage ring building is designed as three parts, i.e., utility area (in the core area), the storage ring tunnel and the experimental hall. The utility area is more divided as two zones. An inner zone of 7m in width and an outer zone of 4m in width, which is next to the storage ring tunnel. There are total 12 control instrumentation areas (CIA) symmetrically distributed along the inner zone of the utility area. Each CIA serves for two sections of the storage ring. There are one AHU, one local DIW system and three AC electrical power feeders equipped for each CIA. There are total 10 AHUs installed on the exit of labyrinth for the storage ring tunnel. There are 18 AHUs distributed along outer area of the experimental and 4 AHUs installed on the utility area serving for the experimental hall. Figure 2 shows the layout of AHUs of the TPS storage ring building. There are three AC electrical power substations distributed on the outer zones of the utility area.

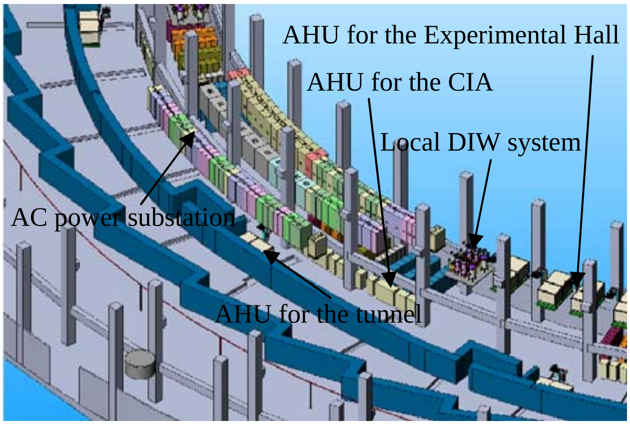

Figure 2: Layout of the storage ring tunnel and technical trenches of the TPS.

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 9789 kW, which is listed in Table 1. The power demand of the main utility equipment installed in the Utility Building III is estimated about 4143 kW. The total power capacity of the TPS is estimated about 13.9 MW.

Table 1: Total power demand for the TPS storage ring.

	power demand (kW)
magnet power-supply system	3540
RF system	3196
other precision devices	2553
Public-utility facilities	500
total	9789

The electrical power system of TPS will be classified according to the power loads. Basically, most power feeders are classified as the technical load or the conventional load. Some subsystems 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 also be installed in the TPS according to the electrical power structure.

A commercial code CDEGS (current distribution for electromagnetic grounding and soil-structure analysis) was applied in design the grounding system of the TPS. The grounding resistance of the TPS was simulated about 0.2Ω. The grounding system will also be classified according to the power loads 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]. 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 four subsystems, i.e., Cu DIW for magnets and power devices, Al DIW for vacuum chambers, RF DIW for the RF facility, booster DIW for booster devices and beam line optical instruments. The specifications of 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	1600 GPM
Al DIW	25 ± 0.1 °C	7.5 ± 0.1 kg	380 GPM
RF DIW	25 ± 0.01 °C	7.5 ± 0.1 kg	1200 GPM
Booster DIW	25 ± 0.1 °C	7.5 ± 0.1 kg	700 GPM
Cooling Tower	32 ± 0.5 °C	3.0 ± 0.2 kg	9000 RT
Chilled Water	7.0 ± 0.2 °C	3.5 ± 0.2 kg	7000 RT
Hot Water	50 ± 0.3 °C	2.5 ± 0.2 kg	1600 kW

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.

As the cooling water circulates in the closed-loop water system year after year, acidic and alkaline ions might cause corrosion and deposition inside the piping. Impurities in water may be basically classified as suspension, electrolyte, particles, microorganisms, organic substances and gases. Various type of impurity can be removed by specific physical or chemical methods.

About 5 % of return water flows into the water-treatment system, which comprises 5-μm filters, resin basins, 1-μm filters, 0.1-μm filters, membranes for dissolved oxygen and ultraviolet lamps. The resupplied water is processed with a Reverse Osmotic (RO) system. The total system requirement must meet a resistivity over 10 MΩ-cm and dissolved oxygen less than 10 ppb.

AIR CONDITIONING SYSTM

A/C system is another critical system related to the thermal effect. As mentioned, the TPS storage ring building is designed as three areas, i.e., utility area, the storage ring tunnel and the experimental hall. The specifications of A/C system of these three areas are listed in Table 3.

Table 3: Specifications of A/C system of TPS.

Location	Total flow rate(m^3/s)	Total cooling capacity(kW)	AHU No.
Exp. hall	135	1811	22
Ring tunnel	56	760	10
CIA	79	1062	12

The computational fluid dynamics (CFD) technique 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, girders, front ends, cable trays and the supply air wind duct are modelled in the simulation. Figure 3 shows the simulated steady state temperature field. Three planes of Z direction are created to check the simulated results, as shown in the figure. The air exhaust, on the exit of the labyrinth is shown on the left side of the figure. The space on the left side is reserved for the insertion devise. The surfaces of all heat sources show higher temperature distribution in orange or red color. The temperature ranges from 20 ^{o}C to 25 ^{o}C.

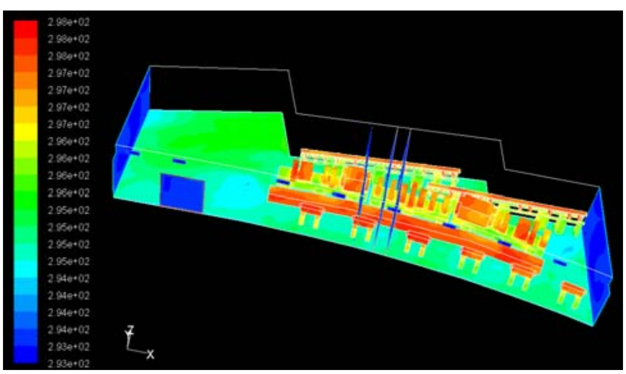

Figure 3: Simulated temperature distribution of the ring.

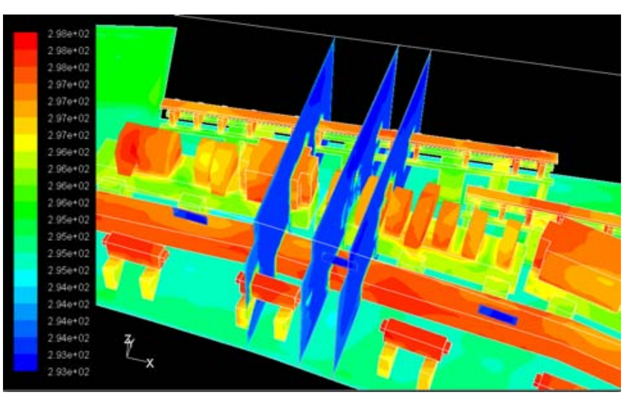

Figure 4: Detailed temperature distributions near magnets.

Figure 4 zooms in on Figure 3 and shows detailed temperature distributions near magnets. It is shown that the temperature of most space in the ring tunnel away from heat sources is close to 20 ^{o}C. The area near the dipole shows clear temperature gradient. The area between two magnets illustrates slight temperature variation of 1-2 ^{o}C while the temperature variation is about 3-4 ^{o}C near the magnet.

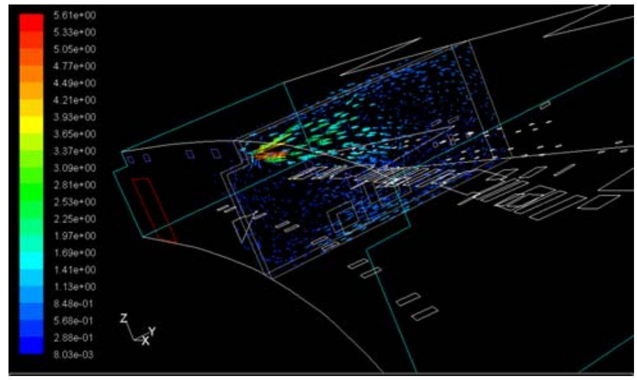

Figure 5: Simulated flow field of the ring.

Figure 5 shows the simulated flow field on two planes. The flow velocity at the exit is higher than that of other area. The air velocity above magnets still keeps about 2-3 m/s. The air velocity of most space away from air exits is almost zero.

CONCLUSION

The utility system layout of the TPS was designed and illustrated in 3D drawing. The electrical power demand and the cooling capacity of the DIW and A/C systems were estimated. Some utility schemes and experiences of the TLS, such as the power load and grounding classification, numerical simulation of the grounding and A/C systems were applied in the design of the utility system of the TPS.

ACKNOWLEDGEMENT

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REFERENCES

1. J.R. Chen et al., "The Correlation between the Beam Orbit stability and the Utilities at SRRC", Proc. of 6th European Particle and Accelerator Conference EPAC98, Stockholm, Sweden, June 22-26, 1998.
2. J.C. Chang, et al., “Design of the Utility System for the 3GeV TPS Electron Storage Ring” The 10th European Particle and Accelerator Conference (EPAC), Edinburgh. UK, June 26-30, 2006.
3. J.C. Chang, et al., “Electrical Power and Grounding System Study and Improvement at TLS” 2003 Particle and Accelerator Conference (PAC), May 12-16, 2003, Portland, USA.