# NUMERICAL SIMULATION AND AIR CONDITIONING SYSTEM DESIGN FOR THE 3GeV TPS STORAGE RING

J.C. Chang*, Z.D. Tsai, C.Y. Liu, Y.C. Chung, and J.R. Chen

a National Synchrotron Radiation Research Center, Hsinchu 30076, Taiwan

* jcchang@nsrrc.org.tw

## Abstract

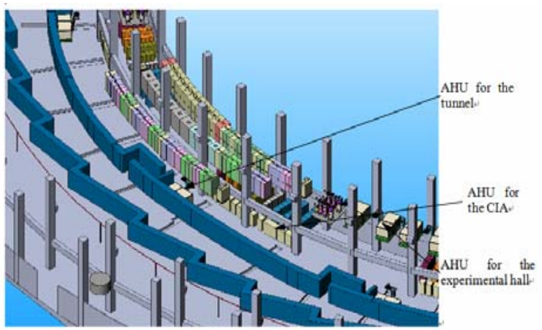
National Synchrotron Radiation Research Center (NSRRC), Taiwan had been approved to launch the Taiwan Photon Source (TPS) project and the utility system design had been started. TPS is designed with 3.0 GeV in energy, 518.4m in circumference and 24 Double-Bend Achromat (DBA). This paper presents the latest design of the Air Conditioning (AC) system for the TPS and numerical analysis results of the air flow and temperature distribution in the storage ring. In the 3-dimensional Computational Fluid Dynamics (CFD) simulation, vacuum chambers, magnets of the booster and the storage ring, girders, cable trays and wind ducts are modelled. The spatial and temporal temperature variations and air flow were demonstrated through the numerical simulation. The cooling load and capacity of the AC system are estimated. The layouts of Air Handling Units (AHU) and wind ducts has been designed and demonstrated in 3-dimensional drawing.

## INTRODUCTION

According to the study of utility effects on the beam stability, thermal effect is one of the most critical mechanical factors affecting the beam stability. Therefore, the design of the AC system of the TPS, especially for the storage ring tunnel, is crucial to the beam stability. Our design, operation, upgrading, and research experience of the TLS AC system is main references in designing the AC system of the TPS. AC systems of some foreign advanced accelerators also provide valuable references. One of our analysis tools is the CFD technique. The TLS has applied the CFD technique on the air-cooling magnet lattice girder, the experimental hall and the storage ring tunnel. The air temperature variation in the storage ring tunnel is globally controlled within ± 0.1°C currently. However, it is believed that a more critical temperature control requirement is needed for the TPS. Therefore, numerical simulation will be applied again in the AC system of the TPS. Especially in the design phase, there is no physical constructed and no actual experiment conducted yet, numerical simulation becomes a valuable analysis tool. We had performed CFD analysis on the preliminary design phase of the TPS AC system. This paper presents important points of design of an AC system, including related concepts, load estimates and planning, and numerical simulation. Design concepts and implementation of the existing AC system and experiences of upgrading the TLS are addressed.

## AC System Cooling Capacity Estimation and Configuration

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 width and an outer zone of 4m width, which is next to the storage ring tunnel. There are 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 two AHUs installed in each CIA. There are total 10 AHUs installed on the exit of labyrinth of 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.




**Layout of AHUs of the TPS storage ring building**

**Specifications of AC system of TPS**

| Location | flow rate($m^3$/s) | cooling capacity(kW) | AHU number |
|---|---|---|---|
| Experimental hall | 135 | 1811 | 22 |
| Ring tunnel | 56 | 760 | 10 |
| CIA | 79 | 1062 | 12 |

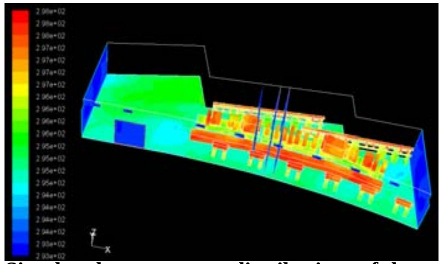
## NUMERICAL SIMULATION

**Boundary conditions of steady state case**

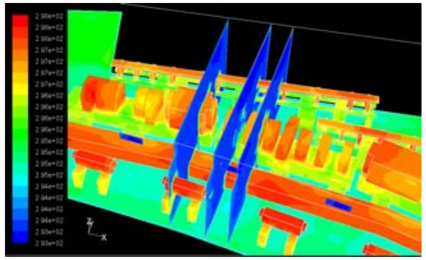
| | | |
|---|---|---|
| Air exit | Air velocity | 5 m/s |
| | Temperature | 20.0 °C |
| Magnets of the storage ring | | 2.0 W/$m^3$ |
| Magnets of the booster | | 1.5 W/$m^3$ |
| Front end | | 2.0 W/$m^3$ |
| Cable tray | | 2.5 W/ $m^3$ |
| Girder, ceiling, wall and floor | | Adiabatic |

**Boundary conditions of unsteady state case**

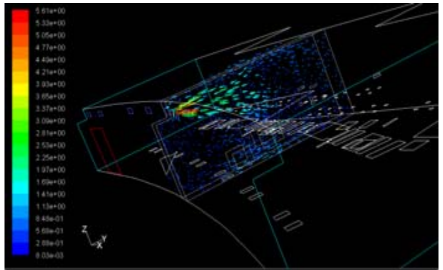
| | |
|---|---|
| Magnets of the storage ring | 2.0 +0.2cos(0.1t) W/$m^3$ |
| Magnets of the booster | 1.5 +0.15cos(0.1t)W/$m^3$ |
| Front end | 2.0 +0.2cos(0.1t) W/$m^3$ |
| Cable tray | 2.5 +0.25cos(0.1t)W/$m^3$ |
| Supplied Air | 20 +1.5cos(0.1t) °C |



**Simulated temperature distributions of the TPS storing ring tunnel**



**Detailed temperature distributions near magnets**



**Simulated flow field of the TPS storing ring tunnel**

**Simulated temperature temporal variation**

| Location | Temp. |
|---|---|
| Above the dipole magnet of the ring | ±0.027 °C |
| Above the dipole magnet of the ring | ±0.012 °C |
| Above the quadrupole magnet of the ring | ±0.021 °C |
| Above the sextupole magnet of the booster | ±0.018 °C |
| Near the girder in | ±0.009°C |
| Near the girder in 20 cm | ±0.004 °C |
| Above the cable tray 10 cm | ±0.031°C |
| Near the air exit 30 cm | ±0.836 °C |

## FUTURE WORK

The simulated results of the steady state show detailed temperature field near the magnets. Eight points respectively above magnets, girders, the cable tray and air exit were selected as monitored points to examine simulated temperature temporal variations. The simulated of the unsteady steady results show smaller temperature temporal variations than the actual case in TLS. A physical model will be constructed to verify the simulated results.