have already been delivered and tested at NSRRC. One IU22-3m and one IUT22-3m were delivered to NSRRC in December 2013; their acceptance test is planned in the first quarter of 2014. Both IU22-3m-2 and IU22-3m-3 will be delivered to NSRRC in December 2014. The EPU46 has also been delivered to NSRRC; the performance of its mechanical structure was improved and the magnetic field was shimmed by the Magnet Group of NSRRC. It is ready for installation in a 7-m straight section in 2014. The construction of two sets of EPU48 is in progress, to be completed in year 2014.

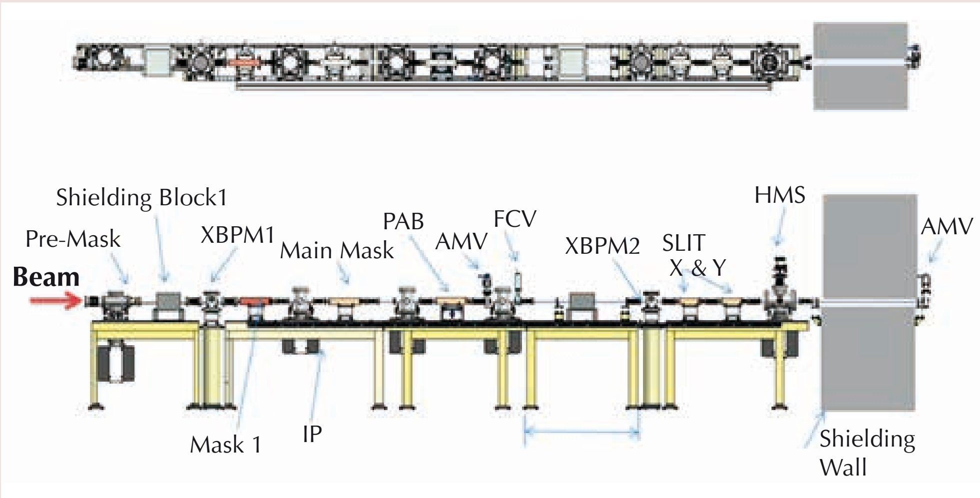

Fig. 11: General ID front-end design.

Highly Precise Temperature Control and Energy Saving for an Air-conditioning System

In an advanced accelerator facility, the performance of the accelerator and any experimental setup are sensitive to thermal effects. The utility system must be designed and constructed carefully to maintain the environment at a stable temperature. During the construction of the TPS building, the concept of a Green Building has been implemented. Decreasing energy consumption is thus an objective toward which NSRRC's Utility Group is striving. The heating, ventilation and air-conditioning (HVAC) system of the utility system has as its function to regulate the thermal energy to maintain a suitable temperature. The components of the HVAC system include dampers, supply and exhaust fans, filters, humidifiers, dehumidifiers, heating and cooling coils, pumps, valves, ducts and various sensors. All these components play a role in affecting directly the control of energy consumption of the HVAC system. Several methods of recovering heat have been studied in the HVAC system to save energy efficiently. A popular approach is to use a run-around coil in the air handling unit (AHU); this method is shown to be effective and can yield a significant saving of energy. The Utility Group has applied this method to a local AHU to maintain the temperature with a fluctuation less than ± 0.05 °C and to produce an energy saving up to 50 %.[1, 2] This method will be subsequently applied to the AHU in the TPS building as an energy saving measure.

In a regular AHU, two heat exchangers serve to adjust the temperature and to decrease the level of humidity in the air. When warm air passes the first cooling coil of the heat exchanger, the heat is carried away by the water, and water molecules in the air

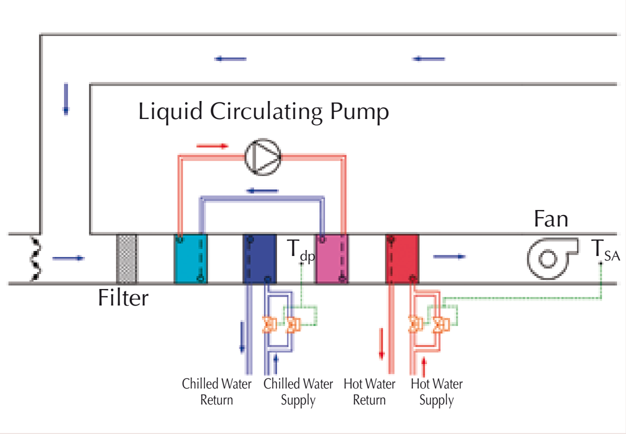

Fig. 1: Block diagram of the highly precise temperature-controlled air-conditioning system.

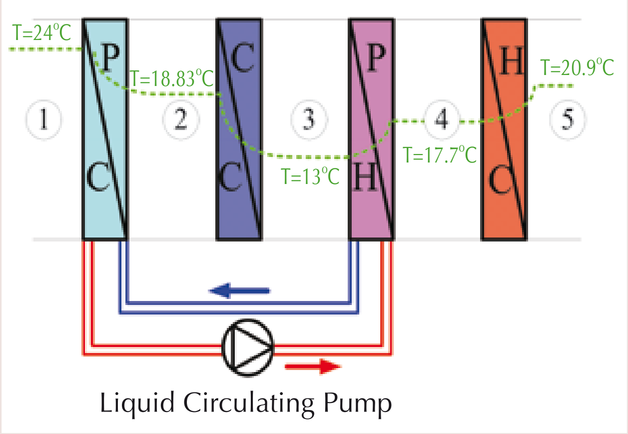

Fig. 2: Block diagram showing the pre-cooling, cooling, preheating and heating coils. The temperatures measured at each stage are shown in the figure.

also condense to water in the exchanger, thus also decreasing the humidity in the AHU. The air then passes through a heating coil of the next heat exchanger to be raised to the desired temperature. Air conditioning of this type wastes much energy. The run-around heat recovery system has an added pre-cooling coil and a preheating coil in the AHU. The openings of the cooling-water valves are controlled by the temperature of the dew point measured between the cooling coil and the pre-heating coil. The openings of the valves for hot water are controlled by the feedback of temperature measured behind the heating coil. This arrangement is shown in Fig. 1. When the air passes the pre-cooling coil, it has a preliminary cooling. In passing the next cooling coil the air is further cooled. The air subsequently passes the preheating coil and the heating coil. The pre-cooling coil and the preheating coil are connected with a circulated pipe to form a loop in which water flows. A small pump is installed in this loop to provide power to move the heated water from the pre-cooling coil to the preheating coil, and then to transfer the heat to the air passing through the pre-heating coil. If the surfaces of the coils and the quantity of circulating water are large, the heat transferred from the pre-cooling coil to the pre-heating coil increases. Because of the exchange of heat by the circulating water between the pre-cooling coil and the preheating coil, the amount of cold water and hot water used for the cooling and heating coils, respectively, can be decreased. The energy consumed by the motor is also small. This method thus cleverly saves energy. A setup of this type can also decrease the need for a dehumidifying and reheating source and thereby decrease the operating cost. In Fig. 2, the temperatures in each stage at which the air passes through the four heat exchangers are shown.

In a traditional air-conditioning system, the water vapor in the air condenses when the return air passes the cooling coil. The absolute humidity thus

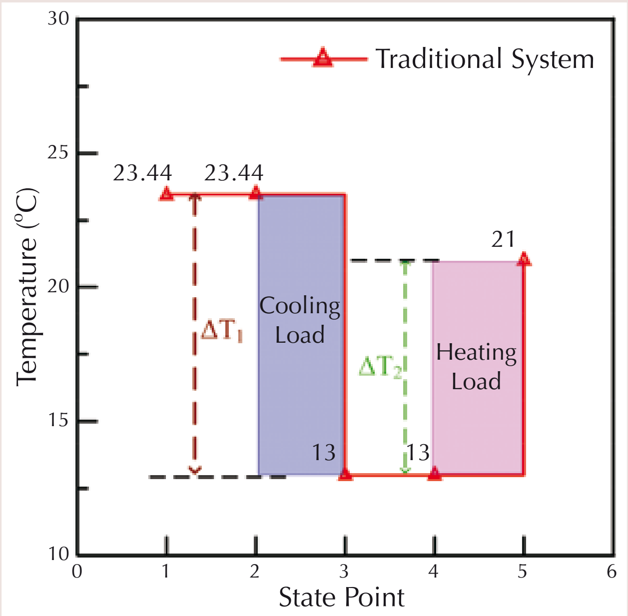

Fig. 3: This block diagram shows the energy consumed in the traditional air conditioning system.

decreases and the relative humidity approaches saturation. The heating coil can serve to decrease the relative humidity to a desired value. Figure 3 shows a diagram of the temperature variation and the quantity of energy consumed during the cooling and heating when the air passes through the heat exchangers. In the figure, the block in blue indicates the load needed to cool the air when it passes the cooling coil; the block in red indicates the load needed to be added to the air when it passes through the heating coil. Much energy becomes wasted when the air must be cooled to less than the dew point with the cooling coil and then be reheated to a desired temperature.

When the run-around mode is in operation, the air passes through the pre-cooling coil and the pre-heating coil before it passes through the cooling coil and the heating coil, respectively. The air thereby becomes pre-cooled and pre-heated first. The temperature differences at the entrances of the cooling and heating coils have been decreased, 4.6 °C and 3.3 °C in our case. Figure 4 is a diagram to show the temperature variation and the quantity of energy consumed in the cooling and heating processes when the air passes through the heat exchangers while the run-around mode is activated. In the figure, the block in blue indicates the load consumed when the air passes the cooling coil; the block in red indicates the load needed when the air passes the heating coil. The blocks in green show the energy saved when the run-around mode is activated.

The variation of the rates of flow of cold and hot water before and after the activation of the run-around mode are shown in Fig. 5. Before the pump for the run-around mode was turned on, the rates of flow of the cold and hot water were evidently 120 and 95 LPM, respectively. After the pump was turned on, the flow rates of the cold and hot water decreased to 80 and 35 LPM, respectively, decreasing the flow rates by 33 % and 63 % for the cold and hot water, respectively. At the same time, the fluctuation of the temperature at the exit of the heating coil was measured to be about ± 0.05 °C; the humidity was about 52 ± 1 %, Fig. 6. During this operation the energy consumed by the circulating pump was estimated to be about 3 %, but the energy consumed by the cooling and heating coils was decreased by 53 %. Much energy was thus saved. If the flow rate of pump in the run-around loop could be increased, more energy would be saved.

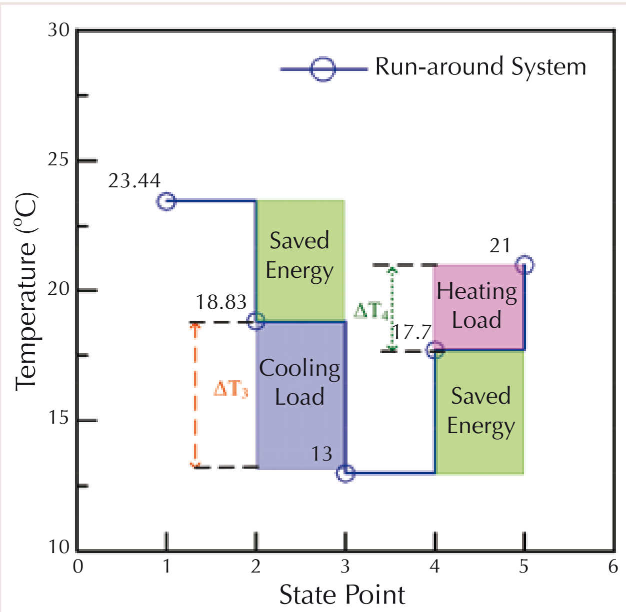

Fig. 4: This block diagram shows the energy consumed and the energy saved when the run-around mode is operational.

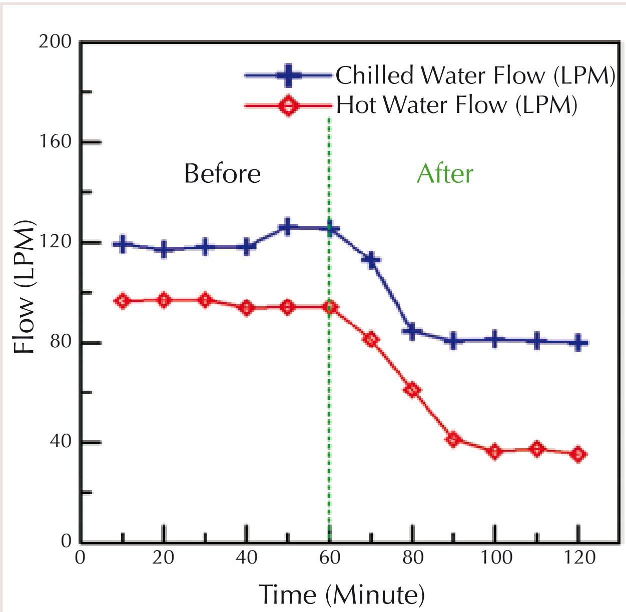

Fig. 5: Variation of flow rates of chilled water and hot water before and after activation of the run-around mode.

During this operation, a commercial controller (NI-PAC) and a 24-bit RTD module with noise level 0.003 °C were used for the precise control operation. PID and fuzzy control schemes were implemented for this system. To control the humidity, the air flow via the cooling coil was controlled based on the temperature of the dew point. The supply air via the heating coil was well controlled within ± 0.05 °C through the feedback of the outlet temperature behind the heating coil. The return air was controlled based on the inlet air temperature by adjusting the fan speed to maintain the room temperature to have a constant gradient for the effect of thermal expansion of the equipment. The flow of water in the run-around system has also been adjusted by the pump speed with an inverter to distribute the thermal energy among four coils.

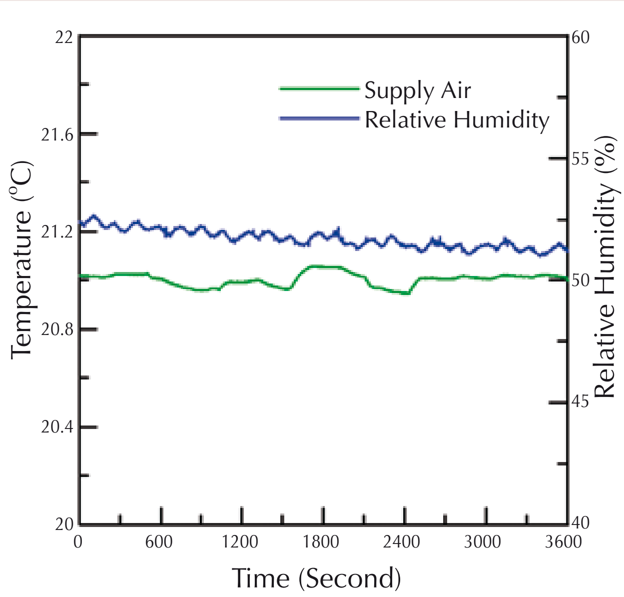

Fig. 6: Trends of temperature of supply air and relative humidity after activation of the run-around mode.

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Highly Efficient Beamline and Spectrometer for Inelastic Soft X-ray Scattering at High Resolution

This report features the work of Chia-Hung Lai and his co-workers published in J. Synchrotron Rad. ***21****, 325 (2014).*

Resonant inelastic soft X-ray scattering (RIXS) techniques have been developed to study the electronic and magnetic properties of strongly correlated electron materials such as transition-metal oxides. L-edge RIXS has proved effective in detecting charge, orbital and magnetic excitations. A RIXS experiment to fulfil the high resolution to study these excitations requires, however, photons of great brilliance and a highly efficient monochromator or spectrometer. Here, we report on the design, construction and commissioning results of a beamline and spectrometer for RIXS at high resolution.

Fung *et al*.[1] proposed a novel design for a RIXS setup comprising two bendable gratings, termed an active-grating monochromator (AGM) or active-grating spectrometer (AGS), to enhance the efficiency of measuring the inelastically scattered X-rays through an increased bandwidth of incident photons, but without smearing the energy resolution. The design of our AGM and AGS is based on the energy-compensation principle of grating dispersion. In adopting this concept, we employed two bendable gratings with varied line spacing (VLS) in the AGM-AGS design for these advantages: an active grating can vary the surface profile to match the desired energy setting and to focus the incident and scattered X-rays onto the sample and detector, respectively; a VLS grating design provides flexible parameters of the ruling density of the grating to cancel the coma abbreviation and asymmetry of the spectral line shape.