An Integrated Air Handling Unit System for Large Commercial Buildings

L.Song and M. Liu

Reducing building energy system operation cost has been the goal of many HVAC design and operation analysis efforts. Commercial building energy systems have been the focus of energy conservation due to their large number and size. HVAC systems in large commercial buildings consume energy in excess of the sum total of the building loads. Large commercial buildings have multi-zones, which can be categorized into interior zone and exterior zones. The exterior zone is taken as the areas that can be affected by the weather directly. It has cooling load in summer and heating load in winter. The interior zone is affected by the internal heat gain only. It needs cooling year round. The excessive energy consumption is mainly caused by reheat consumption of the exterior zone unit. Historically, a signal AHU system (SAHU) is designed as one unit serving the interior zone and exterior zone, at the same time, in order to minimize the initial cost. Due to cooling required by the interior zone unit, significant reheat has been consumed by the exterior zone to satisfy the exterior zone heating load.

A two-dedicated air handling unit system (TAHU), one for the interior zone and another for the exterior zone, was invented to separate the interior zone and exterior zone operation. The cost of the TAHU is significantly higher than the signal AHU system due to its duct layout as well as its separated AHUs. However, the TAHU system provides better comfort control as well as lower energy cost. When the interior zone needs cooling and the exterior zone needs heating, the TAHU system can increase the supply air temperature to reduce the reheat consumption. However, the supply air temperature sometimes cannot be increased due to humidity control during humid season.

A dual path HVAC system has been proposed to decouple sensible and latent cooling by cooling outside air and re-circulation air separately. The minimum outside air can be treated to lower temperatures to remove the excessive moisture and then mixed with partially treated or untreated return air. When the dual path HVAC system is integrated

with single AHU system, it reduces the reheat. However, it still needs reheat when the exterior zone is in heating mode while the interior zone is in cooling mode. The dual path HVAC system may be integrated with the TAHU system to minimize the reheat. However, the integrated dual path and TAHU system further increase the initial cost of the AHU system.

In 1984, a test was conducted to transfer the interior zone heat to exterior zone by using a heat recovery chiller. The heat recovery chiller provides the chilled water to cool the air supplied to the interior zone and provides the "hot water" (condenser water) to warm up the air supplied to the exterior zone. With the same concept in mind, a water loop heat pump system (WLHP) was developed. The water to air heat pump units in each individual zone are connected hydronically with a two-pipe system. The units in cooling cycle reject heat to the pipe system, and at the same time the units in heating cycle retrieve heat from the pipe system to satisfy zone-heating demands. The exterior zone can be heated by interior zone waste heat without introducing external heat. Both heat recovery chiller and water loop heat pump system provide excellent heat recovery from interior zone to exterior during winter. However, both systems bear excessive initial cost.

Taking an integrated system approach, the a new central all-air AHU system was developed for large commercial buildings; the OAHU system. The interior zone return air can be introduced to the exterior zone through a connection duct between the interior zone and exterior zone return air ducts. The internal heat generated from the interior zone can be utilized by the exterior zone before external heating source is required. Significant cooling can also be saved since the exterior zone unit can increase the supply air temperature with no humidity problem.

Energy comparison between the OAHU system and the TAHU system shows that the typical annual thermal energy savings of 24.3 kBtu/ft^2/yr for the hot and humid climate (San Antonio) and 17.2kBtu/ft^2/yr for cold climate (Minneapolis, MN, USA). The addition initial costs of the OAHU system compared with the TAHU system is only from the connection duct and one additional damper.