HVAC : Multizone air handling systems (Converting an ordinary constant volume system to VAV system)

Level: 2nd year students

Pre-requisites:

- Multizone system Air Handler.

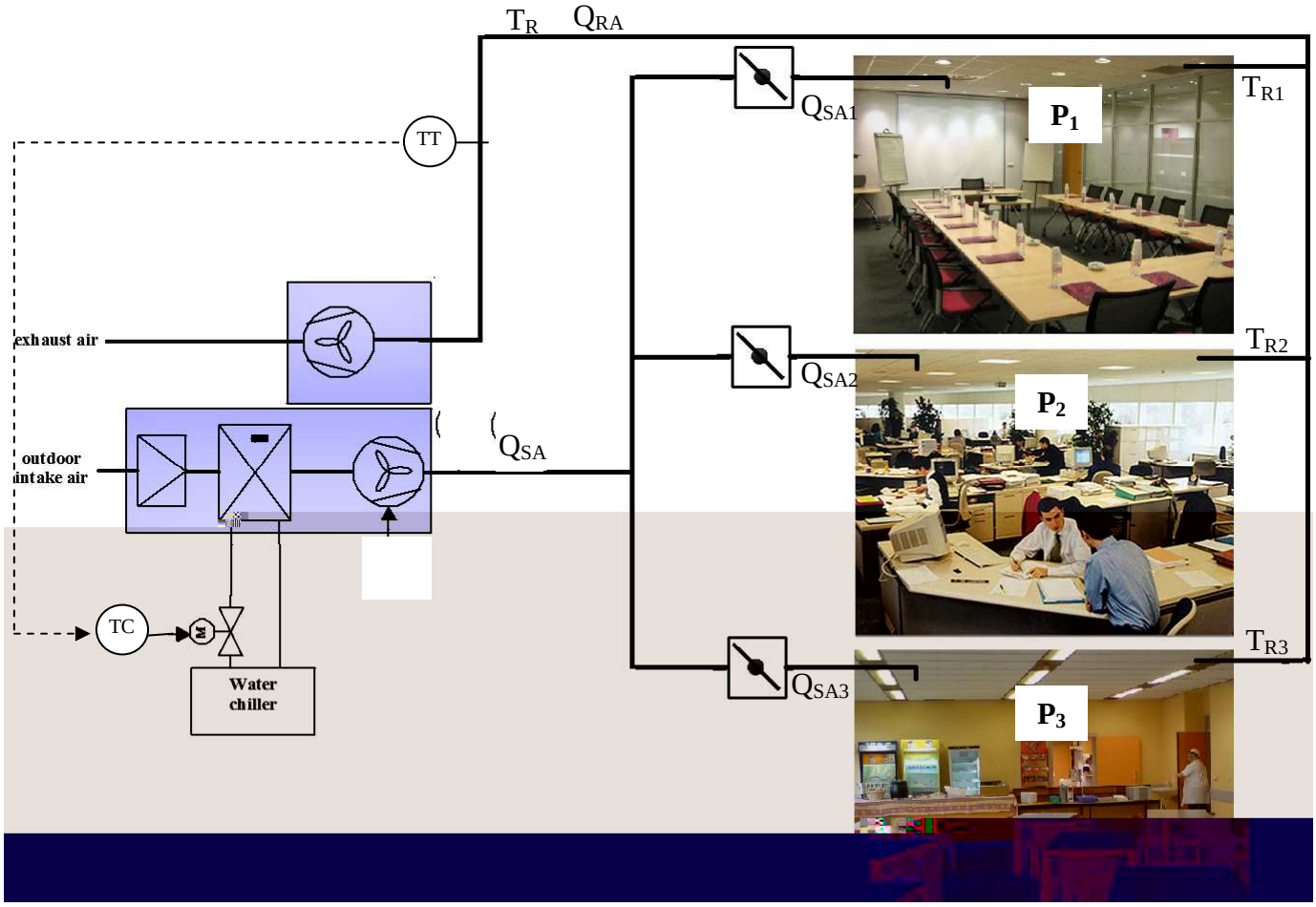
Lessons objectives:

- The student must know in what case he designs a MZVAV system
- The students must know the advantages and disadvantages of such a system.
- The student must be able to list all added devices required for upgrading a CV air handler to VAV.

Pedagogical strategy: Brainstorming to analyze situation, highlight issues, figure out issues and propose solutions. The teacher asks quite a few questions to arouse curiosity and to force students to think about answers in English.

Hypothesis: In this company, the building is divided into three zones. Each zone is characterized by its loads P_i, air volume flow rate (Q_{SAi}), Temperature (T_{Ri}) and Humidity (H_{Ri}). The current system provides a constant return air temperature (T_R) at a constant volume flow (Q_{SA}). Humidity is not controlled.
In order to simplify, we consider a well-balanced ductwork that provides:

$$Q_{SA1} = Q_{SA2} = Q_{SA3} \text{ and } Q_{RA} = Q_{SA}$$



1) Multi Zone Constant Volume systems: highlighting issues.

- *What are the main factors that vary internal loads in each zone?*
  - ***Expected answers:*** *Internal loads vary as a function of the number of occupants. These heat gains, or cooling loads, are basically due to occupants, lights, machines such as computer etc. If zones are empty, there are only external loads that vary temperature.*

- *Using the energy balance equation, and considering hypothesis, write T_R as a function of Q_{SA}, T_{R1}, T_{R2} and T_{R3}.*
  - ***Expected answers:*** $T_R = (1/3).(T_{R1} + T_{R2} + T_{R3})$

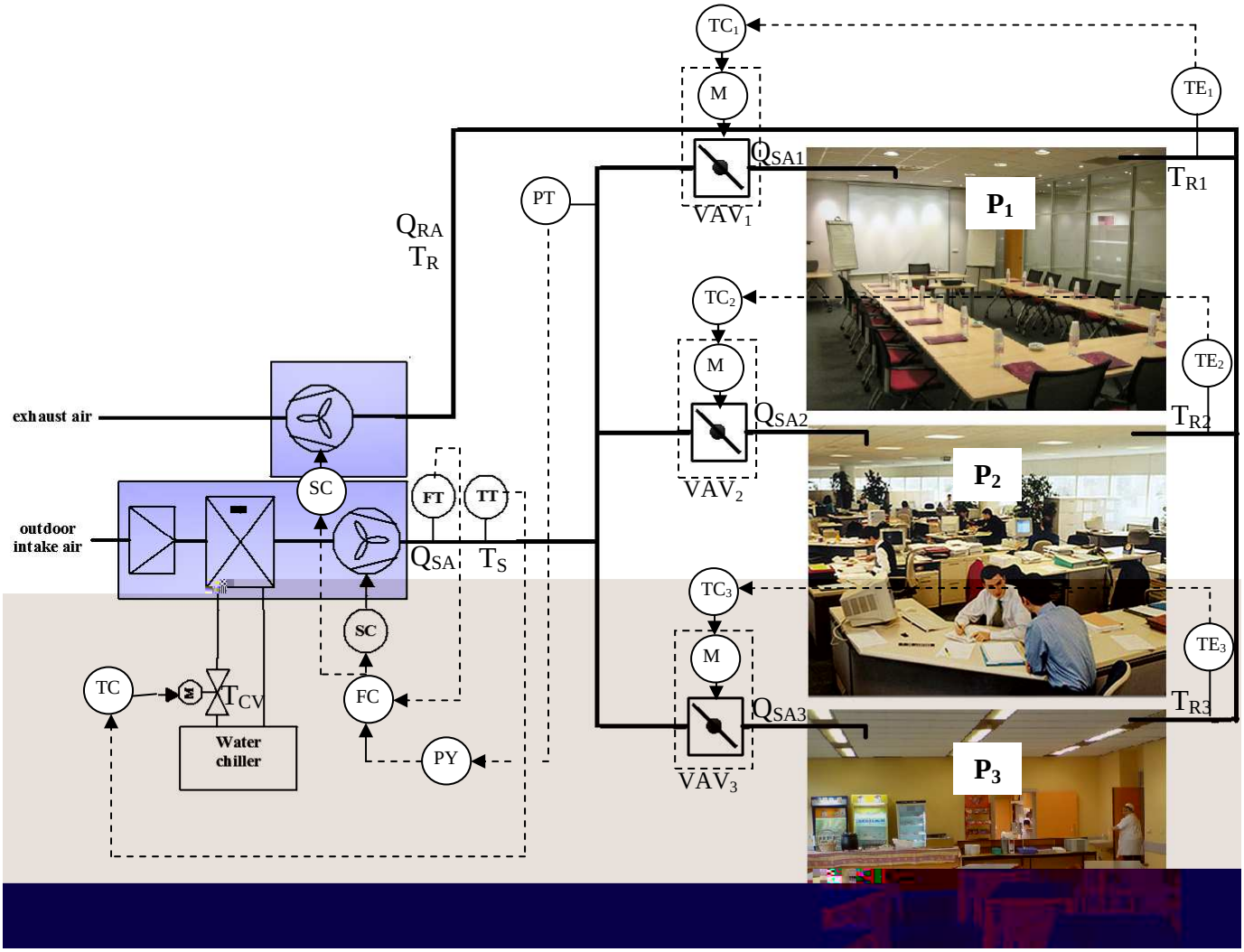
- *Let's imagine this situation: Just after an all-staff weekly morning meeting that went on forever, everybody goes back to their desks. How do internal loads and temperatures vary?*
  - ***Expected answers:***
    - *$P_1 \downarrow P_2 \uparrow P_3 \rightarrow$ then $T_{R1} \downarrow T_{R2} \uparrow T_{R3} \rightarrow$, as a result, T_R remains roughly the same for quite a while and then it increases progressively but slowly.*

- *As regard to the temperature controller, what does this entail?*
  - ***Expected answers:*** *if T_R remains constant for a long time, then TC output value remains the same as well as the cooling capacity. As a result, it's getting warmer in the office. In this situation, at part load conditions, the system is not able to react quickly in order to provide each zone with a comfortable climate.*

2) What would be the solutions to solve these problems?

- ***Expected answers:*** *Each zone temperature must be controlled independently*

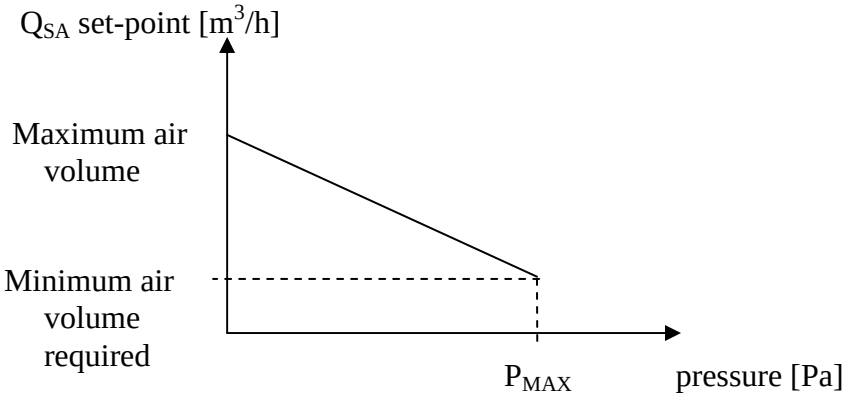
3) How to implement this solution?



- ***Expected answers:***
  - *We can implement a control strategy for each zone (closed loops: TE_i – TC_i – VAV_i).*
  - *Each zone cooling capacity can be controlled by modulating each supply air volume flow rate (Q_{SAi}). This is the function of VAV boxes (Variable Air Volume boxes). But in order to provide each zone with the minimum air volume required for the comfort of occupants, VAV boxes are designed to avoid completely closing the damper.*
  - *This strategy also implies to maintain constant supply air temperature (closed loop: TT – TC - T_{CV}).*

- *Are there any drawbacks, as regard to pressure in ductwork?*
  - ***Expected answers:*** *The drawback is the rise of pressure in the supply air ductwork during low cooling demands, when all dampers are partially closed. Indeed, in that case, the supply air fan has to overcome higher pressure-drop, as a result its electricity consumption increases and also the noise. On top of that, if Q_{RA} remains the same, pressure varies in each zone that may bother occupants.*

- *What is the solution?*
  - ***Expected answers:*** *Pressure must be controlled by reducing the fan speed as well as the supply air volume flow rate. This implies to design a control strategy that maintains constant the static pressure, in the supply air ductwork by controlling the supply air volume flow rate (closed loop: PT – PY – FT – FC – SC)*
    PY operates the following function:



- *Can you sum up the advantages and disadvantages of such a system?*
  - ***Expected answers:***
    - **Advantages :**
      - *Accurate temperature control in each zone*
    - **Disadvantages :**
      - *It's a complex control strategy which implies in-depth knowledge of process control and PID tuning.*
      - *It's a costly investment with return of investment in the long run.*