Tutorial 6: Numerical method – systems

Q1. Discuss the possible approaches to HVAC systems simulation, giving examples of where each approach might be employed and the implications in terms of quality and usefulness of output.

Conceptual modelling is where the characteristic interactions of the HVAC system are modelled but not the detailed processes (inside and between components). For example an air conditioning system may be represented as a convective flux exchange with the room air, with capacity constraints imposed to represent system limitations, control system settings etc. This approach is useful at an early design stage when system details are not available. Outputs include the cooling loads and energy consumption but no information on the internal component states or ability to response to demand.

Detailed modelling requires that an explicit model be created for each plant component and that the entire system be solved simultaneously with the building. Now the full building/HVAC interaction is modelling and the outputs relate to the changes in the working fluids as they pass through the system. Such a model may be used to size equipment and study the behaviour of components and the whole system under transient conditions.

Q2. Compare and contrast the sequential (black-box) and simultaneous (finite volume) approaches to the modelling of a plant component.

The sequential approach uses black-box, input-output models.

+ve:
- suitable for system design (sizing components);
- suitable for checking that components will work together coherently;
- suitable for testing high-level system control strategies.

-ve:
- little or no information on component internal operation;
- fixed parameters most often not valid in off-design conditions.

Simultaneous approach uses an explicit numerical representation.

+ve:
- incorporates a complete description of the fundamental processes within each component;
- can be used to optimise component design;
- does not rely on parameters valid only at the design condition;
- can be used to study control within components and globally.

-ve:
- requires describing information that is not always available from manufacturers

Q3. Describe the energy transport mechanisms within a ground source heat pump.

1. From cold source to refrigerant:
   convection from fluid to heat exchanger surface;
   conduction through heat exchanger wall;
   convection to boiling refrigerant.
2. Evaporation and sensible heating of refrigerant mass flow in the evaporator.
3. Electrical energy converted into potential energy (pressure) and heat (temperature increase).
4. Condensation and sensible cooling of refrigerant mass flow in the condenser.
5. From refrigerant to hot source:
   convection from condensing refrigerant;
   conduction through heat exchanger wall;
   convection from heat exchanger wall to supply air (or water)
6. Expansion (pressure loss and cooling) in valve.