MECH 771 HVAC System Control Strategies and Energy Efficiency


Prerequisite: MECH 672.

This course deals with the most common control strategies based on temperature set point, PMV control, CO₂ set-point, and equipment used to reduce the amount of energy consumed by heating, ventilating, and air conditioning (HVAC) systems using non-derivative optimization techniques. Control strategies and technologies related to gaseous indoor air pollutants. The control strategies analyzed in the course are: scheduled start-stop, day-night setback, optimum start-stop, dead band control, duty cycling, demand limiting and load shedding, economizer and enthalpy cycles, scheduled temperature reset, chiller control and chilled water reset, boiler control and hot water temperature reset, and condenser water temperature reset. Recent developments in HVAC control system hardware, such as pneumatic systems, electro-pneumatic systems, digital-electronic systems, and microcomputer-based control systems, are also discussed. The strategies are studied and compared to each other in terms of cost effectiveness using optimization techniques. Case studies are used to strengthen understanding. Pre-requisite: MECH 672.

Textbook

1. Handouts
2. Research papers

References


Prerequisite by Topic

1. Thermodynamics
2. Control Theory
3. Optimization methods

Educational Objectives

1. To introduce students to common HVAC control devices, control types/actions, and sensors.
2. To introduce students to common control strategies based on temperature set point, PMV control, CO₂ set-point, and equipment used to reduce the amount of energy consumed by heating, ventilating, and air conditioning (HVAC) systems.

3. To provide the student with skills to understand the various control schemes encountered in HVAC systems and assess monitoring and control strategies over life cycle costs.

4. To develop in students the ability to model and formulate optimization problem of any HVAC system operation to minimize energy consumption based on a control strategy.

5. To develop in students the ability to design/select appropriate HVAC control systems for acceptable comfort and IAQ.

6. To introduce software tools for solving optimization of HVAC system operation problems.

**Topics**

- Introduction to control theory and types of control actions.
- Control devices: Temperature, flow, and IAQ, and humidity control.
- Ventilation process and associated mathematical and empirical models. Internal mixing in terms of age distribution models (air exchange efficiency and contaminant removal efficiency).
- Ventilation control strategies and technologies related to gaseous indoor air pollutants.
- Alternative ventilation and air distribution systems.
- IAQ and ventilation system performance and cost.
- Elementary control systems: outside air, air stratification, heating, cooling coils, dehumidifiers, static pressure, electric heating, smoke and fire, refrigeration equipment, location of sensors.
- HVAC systems control strategies: scheduled start-stop, day-night setback, optimum start-stop, dead band control, duty cycling, demand limiting and load shedding, economizer and enthalpy cycles, scheduled temperature reset, chiller control and chilled water reset, boiler control and hot water temperature reset, condenser water temperature reset, pneumatic systems, electropneumatic systems, digital-electronic systems, and microcomputer-based control systems.
- Load-based control strategies, variable temperature strategies, variable air volume strategies, multivariable system control.
- Optimization methods [search methods: non-derivative optimization techniques, neural networks, genetic algorithms, ect.]
- Monitoring, Control and Optimization: development of decentralized control strategies; preview and adaptive controllers; and neural network based HVAC controllers.
- Optimized control strategies.
- Case studies

**Learning Outcomes**

1. The student has the knowledge about HVAC control devices and associated sensors.

2. The student understands most common control strategies based on temperature set point, PMV control, CO₂ set-point, and equipment used to reduce the amount of energy consumed by HVAC systems.
3. Student is able to utilize appropriate modeling, optimization methods, and software tools
to predict optimal operational parameters of the HVAC associated with any selected
control strategy.
4. The student is able to design an HVAC control system that can provide thermal comfort
and air quality with the efficient use of energy.
5. The student is able to solve ‘real-world’ engineering applications of optimized HVAC
control system and present a Case Study via a concise mini-project report.

Assessment

Homework assignments (20%)
Two Mini projects (40%)
One midterm (20%)
Final Exam (20%)

Resources for the course:
The references for the course; the instructor; lectures on Moodle, class notes and handouts; your
teammates; the library; and the web.

Computer usage:
Use of Airpak/Fluent commercial software
Use of Matlab and matlab optimization tools.
Use of Visual DOE 4.0 Energy Analysis Program.