ME 3239 – Combustion for Energy Conversion

Credits and Contact Hours: 3 Credits. Three 50 minute or two 75 minute lectures per week.

Instructors: Baki Cetegen, Tianfeng Lu, Chih-Jen Sung

Textbook: *An Introduction to Combustion: Concepts and Applications*, 2nd edition, by S.R. Turns, McGraw-Hill Publishing, 2000.

Specific Course Information:

a. Catalog Description: Introduction to combustions processes and chemical kinetics. Mechanisms of formation of pollutants such as nitrogen oxides, carbon monoxide, soot and unburned hydrocarbons in stationary and vehicular power plants.

b. Prerequisites: ME 2234

c. Required, Elective or Selected Elective: Elective

Specific Goals:

a. Course Outcomes:

After completing ME 3239 students should be able to:

1. Apply the principals in thermodynamics in combustion systems to describe the states of chemically reacting mixtures
2. Identify the relations to uniquely determine the chemical equilibrium and be able to solve the equilibrium state for simplified systems, e.g. that with constant temperature and pressure
3. Compute finite reaction rates for bimolecular reactions based on the collision theory and for unimolecular fall-off reactions using quasi steady state approximations
4. Apply the law of mass action to obtain the species production rates in multi-step chemical kinetic mechanisms
5. Understand the important kinetic pathways for representative fuels such as hydrogen and methane and higher hydrocarbons, and that for pollutant formation including thermal and prompt NO
6. Compute species concentrations and thermodynamic variables in zero-dimensional reactors, e.g. auto-ignition and stirred reactors
7. Understand the mixture properties such as adiabatic flame temperature, ignition delay, extinction, flammability limits, and flame speed
8. Apply Fick's Law, Newton's second Law, and Fourier's Law to determine the conservation equations for species, momentum, and energy for general reacting flows
9. Distinguish between premixed and diffusion flames and their structures
10. Be familiar with the dominant factors in flames that affects pollutant formation, e.g. NO and soot.

b. Relationship of Course Outcomes to Criterion 3 Student Outcomes:

a) an ability to apply knowledge of mathematics, science, and engineering:

Students acquire the skills to apply the laws of thermodynamics, fluid mechanics, heat transfer and chemical kinetics in mathematical form for the solution and optimization of combustion systems.

b) an ability to design and conduct experiments, as well as analyze and interpret data: *not applicable*

c) an ability to design a system, component, or process to meet desired needs: *not applicable*

d) an ability to function on multi-disciplinary teams: *not applicable*

e) an ability to identify, formulate, and solve engineering problems:
Students are required to apply their gained knowledge to solve combustion problems of different levels of complexity.

f) an understanding of professional and ethical responsibility: *not applicable*

g) an ability to communicate effectively: *not applicable*

h) the broad education necessary to understand the impact of engineering solutions in a global and societal context:
Students learn about the importance of efficient energy utilization from a perspective of limited energy resources (optimization of system efficiency) and pollution prevention (combustion and air pollution).

i) a recognition of the need for, and an ability to engage in life-long learning: *not applicable*

j) a knowledge of contemporary issues:
Students obtain a knowledge of contemporary issues through the design of internal combustion engines (with consideration for pollution aspects), aircraft engines, and land based gas turbine engines.

k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice:
Students learn to use analysis techniques and methods to solve problems in combustion (and where applicable the integration of different subjects) in the design and optimization of combustion systems.

Topics Covered:

- Chemical thermodynamics/equilibrium
- Combustion generated pollutants and their legislated control
- Chemical kinetics
- Governing equations for reacting flows
- Simple chemical reactors: well-stirred and plug flow reactors
- Diffusion flame analysis
- Premixed flame analysis, flame quenching, ignition, flammability limits
- Combustion of liquid fuels: droplet vaporization and combustion
- Combustion of solid fuels
- Pollution control devices