ME 402: Power Plants -- Course Policy

Spring Semester 2008
9:05 AM – 9:55 AM 110 Walker Building

Required Text: *Steam: its generation and use*, 41st Edition. Babcock & Wilcox.
Daily Newspaper: The New York Times

Prerequisite: ME 410: Heat Transfer

Instructor: G. Talmage, Professor of Mechanical Engineering
306 Reber Building (ME Building)
863-3204

Bob Hutchison, Instrument & Meter Technician

Office Hours: MWF 12:30 PM – 2:00 PM

Course Description: This course serves as an introduction to fossil-fuel power plants. The course will begin with a review of two basic cycles and their modifications: Rankine and Brayton. Following a brief introduction to combustion, each subsystem of a power plant will be discussed. The subsystems include fuel preparation and handling, boiler types and the fundamentals of steam generation, water systems (condensate-feedwater, makeup, cooling, and waste), and turbomachinery. During the course, consideration will be given to environmental aspects of power generation as well as operations, maintenance, and controls issues.

This course is being conducted with the full cooperation of the Superintendent and the operators/mechanics of the West Campus Steam Plant (WCSP), with the objective of acquainting students with power generation and to present some of the engineering calculations encountered in practice.

Grading Policy:

Final Grade Construction

Plant Tour	10 %	Tour of one utility plant
ECSP/WCSP Tours	20%	A summary of each tour is due the class following the tour
Homework	10 %	Due Friday at beginning of class, includes NYT assignments
Exam 1	15 %	Monday, February 18 (Evening Exam)
Exam 2	15 %	Monday, March 24 (Evening Exam)
Exam 3	15 %	Monday, April 21 (Evening Exam)
Final Exam	15 %	To be announced by the University – check eLion

Note that the dates of Exams 1 through 3 are tentative.

Typical Letter Grade Construction

A-	90
B-	80
C	70
D	60
F	< 60

Evaluation

Homework: Except for exam weeks, a homework set will be due at the beginning of class on Friday. Each homework set will contain one or more problems representative of the material covered in the previous lectures. It is expected that you solve these problems on your own. Copying problem solutions will lead to disciplinary action, and no credit will be given. A solution to the problems will be placed in the Engineering Library after the due date. No late homework will be accepted.

Exams: Three evening exams (6:30 PM - 7:45 PM) and a comprehensive final exam will be given. The evening exams will be designed as one-hour exams. The exams are closed book, closed notes. An equation sheet identical to the equation sheet provided on the exam will be handed-out prior to the exam.

Absence from an Exam: Makeup exams will be given only under extremely unusual circumstances. A written request for a makeup exam must be presented one week prior to the exam. It is possible that the makeup exam will be oral. In addition, you must apply to the Registrar for a conflict final exam.

Grade Appeal: Within one week after returning a graded exam you may appeal the grading by discussing the points with the course instructor. After one week, no appeals will be accepted.

Cheating on Exams: Students caught cheating will be dealt with according to University Policy.

Class Attendance: It is expected that you attend all classes. Arriving late three times, three unauthorized absences, or any combination thereof may result in an automatic 10% grade reduction.

Late Drop -- deadline April 11: As a reminder, you may drop a course (late drop) up until April 11. However, a WP (passing), WF (failing), WN (no grade) symbol will be entered on your academic record. Whether you obtain a WP, WF, or WN will depend on your performance. Usually, a 70% average on the homework and the exams is sufficient to obtain a WP.

Problem Solving Procedure

Homework problems are to be solved using the procedure outlined below. Homework not following this format will not be reviewed.

1) KNOWN: After carefully reading the problem, state briefly and concisely what is known about the problem. Do not repeat the problem statement.

2) FIND: State briefly and concisely what is to be found.

3) SCHEMATIC: Draw a schematic of the physical system. If application of the conservation laws is anticipated, represent the required control surface by dashed lines on the schematic.

4) ASSUMPTIONS: List all pertinent simplifying assumptions.

5) PROPERTIES: Use a table format to compile property values needed for subsequent calculations. Identify the source from which they were obtained.

6) ANALYSIS: Begin your analysis by applying appropriate conservation laws. Develop the analysis as completely as possible before substituting numerical values. Perform the calculation needed to obtain the desired results. Clearly identify your final results.

7) COMMENTS: Discuss your results. Such discussion should include a summary of key conclusions, an inference of trends, and a critique of the original assumptions.

Additional Remarks:

- Perform all work on one side of the "Engineer's Computation Pad" paper. Do not write on the back of the page. Place your name, the date, the assignment number, and the page number in the right-hand corner of each page.
- Exercise care when treating units. Answers without appropriate units are meaningless.
- Be neat. If your work is sloppy, it will not be reviewed.
- Final answers clearly identified and given to three significant digits.

From *Fundamentals of Heat and Mass Transfer* by Frank P. Incropera and David P. DeWitt. Published by John Wiley and Sons: New York, 1990, pp. 22-23.

ME 402: Power Plants – Tentative
Spring Semester 2008

Required Text

STEAM: its generation and use, 41st Edition, Babcock & Wilcox

Note: **Steam** refers to the 41st edition of **Steam**. "Steam 40" refers to the 40th edition of **Steam**.

In preparation for ME 402, students should be able to:

- Sketch the configuration and draw a T-s diagram for a Rankine cycle and a Brayton cycle
- Indicate the general trends for the ideal cycle (example: for a Brayton cycle, how does the efficiency depend on the pressure ratio, inlet temperature, etc.)
- Define the basic modifications to the simple Rankine cycle and the simple Brayton cycle
- Discuss the significance of the modifications
- State the definition of the adiabatic efficiency for turbines and pumps
- Perform an energy balance analysis on each component of the cycle and the entire cycle
- Interpret the energy balance and availability analysis
- Use the Darcy-Weisbach equation to determine the friction losses in pipes and ducts

Period	Topic	Objective	Reading Assignment
1	The Fundamentals An Overview of a Plant The importance of power generation	List the subsystems and components of a plant	
2	Types of Plants	• Distinguish between the types of plants • Perform a heat balance of the various types of plants[1]	Review material from ME 300
3	Types of Plants	Select between the different types of plants	
4	Types of Plants: A further discussion of the Gas Turbine Cycle	• State the purpose for water injection • Calculate the amount of water required for injection	
5	Walk Through – The WCSP	Sketch the set-up of the WCSP	
6	**Fuel and An Introduction to Combustion**	• List the constituents of coal • Define the two types of analyses performed on coal • Distinguish between high-heating and low-heating values (HHV are used in the United States)	**Steam**, Chapter 9 Steam 40, Chapter 8

[1] These calculations were considered in ME 300 and are, therefore, assumed knowledge.

	Sources of Energy	• State how coal, natural gas, and oil are characterized	
7	Basic Laws of Combustion[2]	Perform a molar evaluation of combustion	**Steam**, Chapter 10 Steam 40, Chapter 9
8	Applications of the Fundamentals – Oxygen and Air Requirements for Combustion	• Define perfect combustion, complete combustion, and incomplete combustion • Determine the amount of oxygen required for complete combustion (based on an ultimate analysis) • Determine the amount of theoretical air required for complete combustion (based on an ultimate analysis) • Discuss the significance of excess air – why is it necessary in the combustion process? • Given an analysis of the flue gas, determine the amount of excess air	
9	Combustion-Gas Products	• Perform an analysis with excess air to determine the weight of the supplied air and the flue gas	
10	Problem Solving Session – Flue Gas Analyses		
11	Energy Balance and Boiler Efficiency	• State the significance of an energy balance • State the major boiler losses • Analyze a boiler in terms of its efficiency – direct and indirect	
12	TOUR: WCSP Coal & Ash Handling All tour dates are tentative – actual dates will be announced in class	• Distinguish between bottom ash and fly ash • Describe methods of handling bottom ash • Describe methods of handling fly ash	**Steam,** 24-12 to 4-21 Steam 40, 23-7 → 23-10
13	Boiler Losses – Examples		
14	Boiler Losses – Additional Examples		
15	**Subsystems and Their Analyses** Fuel Handling and Preparation – Fuel Delivery; Unloading, Initial Preparation, Storage, and Reclamation	• Sketch coal flow and limestone flow	**Steam**, Chapter 12 Steam 40, Chapter 11

[2] You are responsible for:

a. defining a mole,
b. stating the ideal gas law, the law of combining weights, Dalton's law, and Amagat's law, and
c. balancing simple chemical reactions.

16	In-Plant Handling & Ash Handling	• Describe equipment used for in-plant handling of coal • State the types of mills currently used • Describe how a mill operates	**Steam**, Chapter 13 Steam 40, Chapter 12
17	SUBSYSTEMS – Boilers Boiler and Steam Generation Fundamentals	• Describe the essentials of water circulation • State and describe the function of the components of a boiler – steam drum, superheaters/reheaters, economizers, air preheaters, and the stack • Outline a simple plant start-up and shut-down • Match a particular boiler component to ASME Boiler & Pressure Vessel Code	**Steam**, Chapters 19 & 20 Steam 40, Chapters 18 & 19 **Stationary Engineering**, Chapter 5
18	Boiler Types and Firing Techniques	• Compare and contrast the various boiler types and firing techniques	**Steam**, Chapters 14 → 17 Steam 40, Chapters 13 to 16
19	Boiler and Steam Generation Fundamentals		
20	TOUR: WCSP – Boilers and Their Accessories	Sketch the WCSP boiler	
21	Boiler Types and Firing Techniques	• Perform a portion of a performance calculation	**Steam**, Chapter 22 Steam 40, Chapter 21
22	**Water Systems**, Their Components, and Water Treatment – Introduction	• Trace the water systems through a plant • State sources of water • List possible water contaminants and the effects of those contaminants on plant components	**Steam**, Chapter 42 Steam 40, Chapter 42 and 57-10 → 57-18
23	TOUR: Water & Steam Systems	Describe the water/steam systems at the WCSP	
24	Condensate-Feedwater Feedwater Heaters – Open and Closed	• State the purpose of the condenser • Distinguish between OFWH and CFWH • Determine when drain coolers are appropriate • Define TTD and DC and use in calculations	
25	Condensate-Feedwater	• Determine where FWH's should be ideally placed • Discuss what might hinder the ideal placement of FWH's • Perform basic heat exchanger calculations, in particular for the condenser, OFWH, and CFWH	
27	Condensate-Feedwater		
28	Makeup and Cooling Water	• Compare and contrast the various cooling water systems • Calculate the amount of makeup water required • Estimate the height of a cooling tower	
29	TOUR: Piping, Valves, & Traps	Perform very basic calculations	**Steam**, 25-1 → 25-3 Steam 40, 23-5, 6
30	Makeup and Cooling Water		

31	Turbomachinery – Classification	• Classify turbomachines	**Steam**, 57-10 to 57-18
32	Dimensional Analysis and Their Limitations	• Perform a dimensional analysis • State the limitations associated with the dimensional analysis used for turbomachinery and how those limitations can be overcome	Review appropriate chapters from ME 320 textbook
33	Pumps & Fans	• Describe the operation of a pump/fan • Perform basic pump/fan calculations	
34	Pumps & Fans Examples		
35	TOUR: Turbomachinery		
36	Turbines and Generators	• Describe the operation of turbine • Perform basic turbine calculations	**Steam**, 23-10 → 23-25 Black & Veatch, Chapters 8 and 20 Steam 40, 23-10 → 23-25
37	Turbomachinery Calculations		
38	**TOUR: WCSP Control Systems**		
39	Environmental Systems – Particulates, NOx, SOx, CO_2	• State environmental issues associated with power generation • List and describe pollution control techniques	
40	**Environmental Systems**		
41	Environmental Systems		**Steam**, Section IV
42			
43	**Summary**	• Sketch a power plant • Analyze a heat balance, perform an availability analysis of that plant, and interpret the results of those analyses • Sketch the flow of water/steam, coal, and air through a plant • List the subsystems of a plant, indicating the function of each subsystem • Perform basic analyses associated with each subsystem • Select the type of plant appropriate for a given application • Perform an auxiliary power audit • Perform a water audit • Use DoE BestPractices to assess a steam plant	
44	**Summary Continued**		