ME4315 – Energy Systems Analysis and Design

Overview

The design of thermal-fluid and energy systems will be taught using an integrated approach that treats thermodynamics, fluid mechanics, and heat transfer as parts of one interconnected subject. The first half of the course will be devoted to students understanding the underlying physics of thermodynamics, fluids and heat transfer and how it connects to real-life examples. In the second half of the course, students will complete a team based project that involves the design, analysis and optimization of an energy system, which will help to strengthen their skills. The project will require the creation and presentation of a detailed proposal and work plan, along with several presentations at intermediate points during the project and a final presentation. The objective of the proposed course is to develop a physical feel and the skills needed to design any thermal system encountered in life, research or industry.

Course Contents

The physics of thermodynamics, fluid mechanics and heat transfer; A systematic approach to estimation, and cost modeling; Energy system design and analysis using engineering equation solver (EES); Piping systems/fluid flow networks, heat exchanger selection and design; Pumps, fans and compressors. Applications of thermodynamics, fluid mechanics, heat transfer to the modeling and simulation of practical thermodynamic cycles, heat recovery systems, refrigeration and space-conditioning, alternative thermal energy sources, utilization and storage, as well as parametric analyses.

Schedule

Class Meetings: MRDC 2407
Tuesday, Thursday 8:05-9:25 AM

Assessment

Attendance & Participation 15%
Tests 30%
Project Proposal and Updates 30%
Final Report & Presentation 25%

Instructor

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Reference Materials

H. A. Sorensen, *Energy Conversion Systems*, Wiley, 1983
R. F. Boehm, *Design Analysis of Thermal Systems*, John Wiley and Sons, 1987
R. A. Granger, *Experiments in Heat Transfer and Thermodynamics*, Cambridge, 1994
E. C. Guyer, *Handbook of Applied Thermal Design*, McGraw-Hill, 1988
W. S. Janna, *Design of Fluid Thermal Systems*, PWS-Kent, 1993
B. K. Hodge, *Analysis and Design of Energy Systems*, 2nd Ed., Prentice Hall, 1990
W. F. Stoecker, *Design of Thermal Systems*, 3rd Ed., McGraw-Hill, 1989
A. Bejan, G. Tsatsaronis, and M. Moran, *Thermal Design and Optimization*, Wiley, 1996

Design Project Organization

Overview – The topics covered in lectures and the knowledge/guidance students gain through in class discussions of each project's progress, will be applied to their own respective semester-long project involving the detailed design of a complete thermal system. The objective is to translate a problem statement into design tasks and execute them, while demonstrating technical proposal, presentation and report writing skills, much like you would in R&D or industry. The project topics are listed in Table 1 and the projects will be conducted in groups of 4-6 students. Students will submit project preferences and will be assigned to a group after which they will develop a 3-5 page project proposal document with a detailed work plan. The proposal will be presented in class and based on the feedback provided, the proposal must be revised and approved before the work plan is executed. The team will present 10-15 min progress reports for each project 3-4 times throughout the semester, followed by in depth discussion during class. The project will culminate in the submission of a final report and a 15 min in class presentation and all students are required to attend the presentations of all project groups.

Project Proposal – The proposal must include the objective of the project, the approach and tasks to be performed to achieve the objective (i.e., a step-by-step approach to calculating the design requirements, the design of components, the integration of components into systems, and optimization of the systems), and a schedule for these tasks. Each student in the team must have a well-defined leadership position for some aspect of the project, which should be clearly articulated in the proposal. This will be reviewed and modifications will be suggested by the instructor based on the scope and approach proposed by the students. Once the proposal is approved with modifications from the instructor, the students will execute the work plan.

Update Presentations – Teams will present a progress report in class followed by discussion involving the entire class on a weekly basis (approximately). The discussions will be used to guide all other teams through the various challenges they may encounter with their respective projects. Each update presentation should last 10 min and should contain the following content: (1) A brief review of the project, the design and work plan [1-2 min], (2) A review of progress to date, emphasizing current results, challenges encountered and unanswered questions [7 min], (3) A discussion of future work and anticipated challenges [1-2 min]. Students should also provide hypotheses and estimates for the expected behavior or performance of certain aspects of the system based on their intuition/reasoning. Model results should then be compared to these predictions facilitating discussions that will help the entire class refine its intuition.

Final Report and Presentation – At the end of the project, a comprehensive design report must be submitted. The final report should be done in a professional manner, with references, appendices, table of contents, etc. Please note that the numerical solution to the problem is the beginning, rather than the end of the assignment. Extensive discussion on identified bottlenecks, the effects of changes in the design constraints and component geometry on performance must be demonstrated through parametric analyses. Extensive and explicit discussion should also be devoted to why the chosen design is optimal for meeting the objectives. The final presentation should consist of a concise summary of the project, results, what was learned and review of the intuitive predictions as compared to the results. The presentations will be 15 minutes long (including time for 1-2 questions from the instructor).

PROJECT GRADING/ASSESSMENT – Each student will receive a separate grade for the project. Each student's project grade will be determined from the average of the grade earned by the group as a whole, and the grade earned by each individual. For example, if the group receives 95% (an "A") for the project, but student 1 in the team receives a 100% ("A") individually for doing most of the work, while student 2 receives a 60% ("D"), then student 1 will receive a 97.5%, while student 2 will receive a 77.5% for the project portion of the grade. This rubric will be applied separately, but in the same manner to both the proposal and project update portion of the final grades (30%), as well as to the final report and presentation portion of the grade (25%). Therefore 55% of each student's grade will be determined by the performance of their team along with their individual contributions. This rubric is intended to reward the group for working well together, but to also penalize team members who do not contribute.

The group's grade for the proposal, presentations and final report will all be determined directly from the instructors' qualitative assessment. This assessment will include factors such as: the quality of technical analysis (e.g., Is it correct? Is it thorough?) [worth ~ 60%], the quality of presentation (e.g., Was it well thought out? Were the results and explanations conveyed clearly?) [worth ~ 20%] and the students' ability to field questions (e.g., Did the team know the answers to the questions? Were the questions answered clearly and concisely?) [worth ~ 20%]. This rubric is approximate and the instructor reserves the right to adjust these approximate weightings as desired.

The individual grades for each student's portion of the project will be determined by several factors. The first will be a qualitative assessment by the instructor. All group members are required to attend each presentation (proposal, updates and final). Blocks of days will be allocated for presentations, but the **presentations will not be scheduled in a given order**. The instructor will call groups to present (in no particular order) **at any time** during the associated blocks of days devoted to either proposal, update or final presentations. Thus, students must come to each class meeting prepared to give their presentations for a certain block of days. Furthermore, the instructor may require that **any group member** give the entire presentation, some portion, or answer a particular question. This is to ensure that all team members stay up to date on all aspects of the project. After each update presentation, the students in the team that presented must fill out and turn in a form whereby they rate all team members' participation and performance on the project. These forms should be submitted without sharing the respective opinions between the team members and will be used by the instructor to help in determining if a particular team member's effort/performance is substandard.

Table 1

Topic #	Project Topics
1	A Dry Cooled Condenser for a Steam Based Power Plant
2	An Energy Efficient Office Building
3	Compressed Air Energy Storage
4	Concentrated Solar Power Plant
5	Energy Efficient Home with Concentrated Photovoltaics
6	Thermal Energy Storage of Electricity
7	Carbon Capture from a Coal Fired Power Plant