Engineering Tripos Part IIA, 3A5: Thermodynamics & Power Generation, 2018-19

Module Leader

Prof E Mastorakos [1]

Lecturers

Prof E Mastorakos and Dr A J White

Lab Leader

Dr A J White [2]

Timing and Structure

Michaelmas term. Thermodynamics 2 lectures/week, weeks 1-4 (Dr A J White); Power Generation: 2 lectures/week, weeks 5-8 (Dr G Pullan). 16 lectures.

Aims

The aims of the course are to:

- Focus on electricity power generation and the underlying thermodynamic theory.
- Cover topics including power generation by gas, steam and combined cycles, and direct electrochemical conversion by fuel cells.
- Introduce some advanced cycle concepts and discuss the possibility of carbon dioxide capture and storage.

Objectives

As specific objectives, by the end of the course students should be able to:

- Understand the principles of exergy analysis, be able to calculate the lost work terms of power cycle components.
- Know the importance of the Helmholtz and Gibbs functions, the uses of standard property changes in chemical reactions, and the idea of rational efficiency..
- Understand the principles of electrochemical energy conversion, be aware of different types of fuel cell technology, be able to calculate the Gibbs and Nernst potentials, and have a basic knowledge of fuel cell losses.
- Understand the principles of phase equilibrium, the role of the chemical potential, and the Clausius-Clapeyron equation.
- Understand equation of state theory including characteristic form, Maxwell's relations, ideal gases, ideal gas mixtures, imperfect gases, van der Waals form, and law of corresponding states.
- Understand chemical equilibrium theory and the use of the equilbrium constant, be able to perform calculations for gas mixtures with one or two independent reactions, and be able to apply van't Hoff's equation.
- Understand the rôle of steam and gas turbine cycles in electricity power generation and be conversant with likely future developments.
- Be able to evaluate the performance of gas turbine plants including reheat, intercooling and recuperation.

- Be able to evaluate the performance of steam power plants including reheat and feedheating.
- Be able to evaluate the performance of combined cycles.
- Understand the issues involved in the capture and storage of carbon dioxide from fossil-fuelled power plants.

Content

Thermodynamics (8L)

- Thermodynamic availability, lost work and entropy production, exergy analysis, application to power cycles.
- Gibbs and Helmholtz functions, standard property changes in chemical reactions, overall and rational efficiencies, electrochemical conversion, fuel cells (theory and practice).
- Equilibrium criteria, phase equilibrium, chemical potential, Clapeyron equation, equations of state, ideal gas mixtures, imperfect gases, van der Waals equation.
- Gibbs equation, chemical equilibrium, chemical potential of ideal gas, equilibrium constant, gas phase reactions, van't Hoff equation.

Power Generation (8L)

- Overview of current and future electricity power generation, and the associated carbon emissions.
- Gas turbines with intercooling, reheat and recuperation. Turbine blade cooling.
- Steam cycles with feed heating and reheat. The combustion process and boiler efficiency.Steam cycles for nuclear power.
- Combined gas-steam cycles.
- Advanced cycles and carbon dioxide sequestration.

Coursework

Computer based cycle simulation

Learning objectives:

- To consolidate the concept of exergy covered in lectures, and to apply this to the analysis of power-generating gas turbine cycles.
- To study the methods by which the efficiency and specific work output of a simple gas turbine plant may be improved.
- To investigate trends in cycle performance with various design parameters.

Practical information:

- Sessions will take place in the DPO, during weeks 1-6.
- This activity doesn't involve preliminary work.

Full Technical Report:

Students will have the option to submit a Full Technical Report.

Booklists

Please see the **Booklist for Part IIA Courses** [3] for references for this module.

Examination Guidelines

Please refer to Form & conduct of the examinations [4].

UK-SPEC

The UK Standard for Professional Engineering Competence (UK-SPEC) [5] describes the requirements that have to be met in order to become a Chartered Engineer, and gives examples of ways of doing this.

UK-SPEC is published by the Engineering Council on behalf of the UK engineering profession. The standard has been developed, and is regularly updated, by panels representing professional engineering institutions, employers and engineering educators. Of particular relevance here is the 'Accreditation of Higher Education Programmes' (AHEP) document [6] which sets out the standard for degree accreditation.

The Output Standards Matrices [7] indicate where each of the Output Criteria as specified in the AHEP 3rd edition document is addressed within the Engineering and Manufacturing Engineering Triposes.

Last modified: 15/05/2018 14:12

Links
[1] mailto:em257@cam.ac.uk
[2] mailto:ajw36@cam.ac.uk
[3] https://www.vle.cam.ac.uk/mod/book/view.php?id=364091&chapterid=46241
[4] http://teaching.eng.cam.ac.uk/content/form-conduct-examinations
[5] http://www.engc.org.uk/ukspec.aspx
[6] http://www.engc.org.uk/standards-guidance/standards/accreditation-of-higher-education-programmes-ahep/
[7] http://teaching.eng.cam.ac.uk/content/output-standards-matrices