Engineering Tripos Part IIA Project, GA1: Advanced-cycle Power Generation, 2024-25

Leader

Prof R J Miller [1]

Timing and Structure

Thursdays 11-1pm, and Mondays 9-11am plus afternoons

Prerequisites

3A5 Strongly recommended

Aims

The aims of the course are to:

- Appreciate the thermodynamic engineering and economic principles, and the environmental impact, of power generation using advanced fossil fuel power stations, hydrogen power stations and long term energy storage to support renewables.
- To use cycle analysis computer codes to perform parametric studies of various types of cycle in a variety of economic scenarios and ultimately to select, design and optimise a power plant for a specified operational role.

Content

The power generation industry is being transformed. In some parts of the world coal power stations are being rapidly replaced by advanced natural gas power stations. In other countries, where natural gas is not available hydrogen power stations are under construction. In other countries the rapid expansion of renewables has led to a requirement for long term energy storage to ensure grid stability. The objective of this course is to investigate a range of advanced thermodynamic cycles and to understand how they can be used to practically accelerate the grid towards net zero.

Cycle analysis is currently an extremely active area of research, with many new and novel cycles being proposed. Examples include gas turbine cycles with water or steam injection, cycles incorporating fuel cells, and hydrogen cycles. Some of these cycles promise extremely impressive thermodynamic performance, often at considerably lower capital cost than the combined-cycle.

In this project you will in teams of three undertake a computer-based investigation of combined-cycles and some of the above-mentioned advanced cycles, using a suite of especially written computer programs. (The analysis programs are written in FORTRAN, but a knowledge of this language is not required: for the most part you will use the programs with no or little modification. Some of the visualisation programs are written in Matlab code with which you should be familiar from Part I.)

Cycle analysis and design is a complex procedure requiring comparatively elaborate calculations and it is virtually impossible to perform even the simplest design-point optimisation without the help of such programs. However, the project is structured in such a fashion that you should develop a firm understanding of the thermodynamic principles that underpin the operation of power generating plant. This understanding is essential to the innovation of new power generating cycles.

Computer investigation of simple and advanced cycles. Appreciation of thermodynamic principles (including second law exergy analysis) and environmental impact via parametric studies of (i) gas turbine, steam turbine and combined cycles, considering multiple figures of merit (efficiency, specific work, cost of electricity) in multiple economic scenarios, (ii) hydrogen gas turbines, (iii) the use of long term hydrogen storage to support renewable grid stability.

Further notes

Examples papers

Coursework

Coursework	Due date	Marks
First *Individual* report	TBA	20
First *team* report	TBA	20
Second *individual* report	TBA	20
Second *team* report	TBA	20

Booklists

Examination Guidelines

Please refer to Form & conduct of the examinations [2].

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Links
[1] mailto:rjm76@cam.ac.uk
[2] https://teaching.eng.cam.ac.uk/content/form-conduct-examinations