Engineering Tripos Part IIA Project, GA1: Advanced-cycle Power Generation, 2020-21

Leader

Dr L Xu [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 combined gas turbine and steam cycles, and other advanced cycles
- 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 past two decades have seen a technical revolution in the power generation industry. This has been driven by rapid developments in gas turbine technology, the large-scale use worldwide of natural gas as a fuel, and the increased level of awareness concerning the consequences of environmental pollution. Since the early 1990s, thermal efficiencies of the best power stations have risen from 40% to 55% and are now approaching an astonishing 60%. These very high efficiencies are usually achieved by using a gas turbine to top a steam cycle, the so-called combined-cycle power plant.

However, 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 cycles exploiting coal gasification. 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 cycles. Appreciation of thermodynamic principles (including second law exergy analysis) and environmental impact via parametric studies of (i) the steam cycle with reheat and feedheating, (ii) the combustion process, and (iii) the gas turbine with reheat, intercooling and heat exchange, considering multiple figures of merit (efficiency, specific work, cost of electricity) in multiple economic scenarios.

Assessment of different configurations of combined-cycle plant. Computer analysis of the single pressure, exhaust-gas heated combined cycle. Investigation of the effects of different fuels (on cycle efficiency and atmospheric pollution), feedheating, preheating loops, multi-pressure steam generation, gas and steam turbine reheat, etc. Again, multiple figures of merit and economic scenarios will be considered.

Assessment of different configurations of advanced-cycle power plant. A choice of cycles will be available at this stage. Between you, your team will investigate the performance attributes of a number of these cycles in the same contexts as the previous investigations.

Further notes

Examples papers

Coursework

Coursework	Due date	Marks
First *Individual* report	Thursday 14 May 2020	20
First *team* report	Thursday 21 May 2020	20
Second *individual* report	Thursday 28 May 2020	20
Second *team* report	4pm Thursday 4 June 2020	20

Booklists

Examination Guidelines

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

Last modified: 30/11/2020 08:59

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[1] mailto:lpx1@cam.ac.uk
[2] https://teaching22-23.eng.cam.ac.uk/content/form-conduct-examinations