Engineering Tripos Part IB, 2P8: Aerothermal Engineering, 2019-20

Lecturers

Dr A Wheeler and Dr C Hall [1]

Timing and Structure

Easter Term: 14 lectures + 2 examples classes, 4 lectures/week.

Aims

The aims of the course are to:

- Understand why current engines on large airliners look as they do, how they work and how they are specified.
- Determine what is needed to propel a new large airliner.
- Appreciate the mixture of physical modelling and empirical input necessary to make the decisions to allow a design to proceed, as well as the need for compromises.

Objectives

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

- Calculate the major parameters of the engine (this will be carried out in the form of exercise questions throughout the course).
- Make appropriate design choices for engine components.
- Sketch a cross-section of the engine showing principal components with appropriate parameters.
- Calculate the effect of speed and altitude on engine performance.

Content

Modern jet engines are amongst the most expensive mechanical engineering devices to design and develop; a new engine is expected to cost several billion pounds. Why is it so expensive? Why do they look the way they do?

Many of the most important decisions are taken at an early stage of design using fairly simple procedures, similar to those that can be used in lectures and example classes. The constraints, especially those associated with material properties, need to be known or specified, together with estimates for the likely level of aerodynamic performance. From these the desirable type of engine configuration can be specified, preliminary choices for the main components (compressor and turbine) can be made and a sketch of the engine layout can be drawn.

Introduction to Aircraft Propulsion

- Operating principles,key aircraft parameters, nacelle/wing arrangements
- Design constraints, environmental issues and fuel burn.

Aircraft performance

- Basic aircraft aerodynamics, sizing the wing, lift-drag relationships.
- Breguet range equation, estimation of aircraft fuel burn and emissions.

- Thrust requirements, trade-offs between weight and performance.

Generation of thrust

- Momentum analysis, propulsive efficiency, overall efficiency.
- Choice of engine type for given duty; high subsonic cruise compared with supersonic operation.

Thermodynamic Analysis of Gas Turbine

- Power generation: effect of pressure ratio, temperature ratio and component efficiency.Relationship between thermal efficiency and cycle efficiency.
- Jet propulsion as a means for utilisation of power.

Choice of Engine

- Selection of bypass ratio and calculation of corresponding engine mass flow.
- Turbine inlet temperature and blade cooling.
- Calculation of fuel consumption in determining fan diameter.

High Speed Flow of Gas

- Subsonic and supersonic flow, nozzle flow, choking.

Dimensional Analysis

- Dynamic scaling of jet engine.
- Start-of cruise is the design condition - estimating thrust and fuel consumption at off-design conditions, such as take off.
- To consider requirements for thrust in case of engine failure at take off or cruise.

Turbomachinery Principles

- General introduction to operation of compressors and turbines.
- Selection of number of stages in compressor and turbine.

Appraisal of Design

- Having specified overall size, bypass ratio, turbine inlet temperature, sketch engine layout and compare with existing designs.

Booklists

Please see the Booklist for Part IB Courses [2] for references for this module.

Examination Guidelines

Please refer to Form & conduct of the examinations [3].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [4] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

IA3

Comprehend the broad picture and thus work with an appropriate level of detail.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

D1

Wide knowledge and comprehensive understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations.

D2

Understand customer and user needs and the importance of considerations such as aesthetics.

D3

Identify and manage cost drivers.

S1

The ability to make general evaluations of commercial risks through some understanding of the basis of such risks.

S3

Understanding of the requirement for engineering activities to promote sustainable development.

E1

Ability to use fundamental knowledge to investigate new and emerging technologies.

E2

Ability to extract data pertinent to an unfamiliar problem, and apply its solution using computer based engineering tools when appropriate.

E3

Ability to apply mathematical and computer based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

P1

A thorough understanding of current practice and its limitations and some appreciation of likely new developments.

P3

Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology, development, etc).

P5

Awareness of nature of intellectual property and contractual issues.

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

US3

An understanding of concepts from a range of areas including some outside engineering, and the ability to apply them effectively in engineering projects.

US4

An awareness of developing technologies related to own specialisation.

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