Engineering Tripos Part IIB, 4A13: Combustion & IC Engines, 2018-19

Module Leader

Prof N Swaminathan [1]

Lecturers

Prof N Swaminathan and Prof E Mastorakos/Prof G Kalghatgi

Timing and Structure

Lent term. 16 lectures, including 2 examples classes. Assessment: 100% exam

Prerequisites

3A5, 3A6 useful

Aims

The aims of the course are to:

- introduce students to fundamental combustion concepts, and their influence on internal combustion engine preformance and emissions.

Objectives

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

- Understand fundamental concepts in combustion
- Understand combustion issues particularly relvant to gas turbines
- Understand the performance and efficiency characteristics of IC engines
- Understand the formation and aftertreatment of pollutants in IC engines, and tradeoffs with performance

Content

Chemical thermodynamics and equilibrium (1L)

Conservation laws for multicomponent mixture, multispecies equilibrium and calculation method

Chemical kinetics (1L)

Principles of chemical kinetics – law of mass action, activation energy, order & degree of a reaction, hydrocarbon reaction chains?, pollutant formation ?multistep reactions, chemical explosion, chemistry reduction using steady state and partial equilibrium approximations

Applications of chemical kinetics: limit reators (1L)

Common approximations used in combustion analysis – perfectly stirred reactor, plug flow reactor, thermal explosions, autoignition & spark ignition

Laminar premixed flames (1L)

Concepts and measurements,? conservation equations in one and multiple dimensions, characteristic time and space scales, Zeldovich number, solution for 1D flame, flame speed and its dependence on mixture composition, temperature and pressure

Laminar non-premixed flames (1L)

Mixture fraction concept and its physical significance, conserved scalar approach, state relationship, simple solution for diffusion flame, droplet combustion as an example for diffusion flame

Pollution from Combustion (1L)

Nature of pollution emitted by combustion and its effect on environment & human health, features of pollution generation chemistry, typical techniques used for emission reduction

Turbulent Combustion (1L)

A brief introduction to turbulent combustion, its importance, applications, and scientific methods used to study turbulent combustion

Introduction to Internal Combustion Engines (1L)

Types of engines – Spark Ignition Engines, Diesel Engines, Homogeneous Charge Compression Ignition (HCCI) Engines; Thermodynamic cycles and Efficiency; Emissions control

Outlook for Energy and Transport (1L)

Transport energy outlook – drivers for change, prospects for alternatives to internal combustion engines and conventional fuels, challenges of full electrification, importance of internal combustion engines and the necessity and potential for improving them

Practical Transport Fuels (1L)

Composition, properties, manufacturing, & specifications

Deposits in Engines and Fuel Additives (1L)

Fuel system, intake system and combustion chamber deposits in SI engines, diesel injector deposits in diesel engines, mechanisms of formation, effects on engine performance and operation, controlling methods

Fuel Anti-Knock Quality and Knock in SI Engines (1L)

Knock and SI engine performance, fuel antiknock quality, RON, MON and octane index, lessons learnt from HCCI studies, future fuel requirements

Insights into knock onset, knock intensity, superknock and preignition (1L)

Knock fundamentals, ignition delay and Livengood-Wu integral, stochastic nature of knock, knock intensity, developing detonation and superknock, difference between preignition and superknock, application of fundamental insights to practical understanding

Fuel effects in compression ignition engines (1L)

Particulate/NOx control and ignition delay, Gasoline Compression Ignition (GCI) engines, fuel effects, advantages, challenges and prospects for GCI, dual fuel approaches to low NOx/low soot combustion

Evolution of future transport energy and implications for future fuels (1L)

Summary of previous 7 lectures. Future fuels and engines

Booklists

Please see the Booklist for Group A 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.

IA2

Demonstrate creative and innovative ability in the synthesis of solutions and in formulating designs.

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.

E1

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

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).

US1

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

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