Combustion and transport phenomena

Academic Year: (2023 / 2024) **Review date: 19-01-2024**

Department assigned to the subject: Aerospace Engineering Department

Coordinating teacher: PEREZ ENCINAR, MIGUEL

Type: Compulsory ECTS Credits : 3.0

Year : 1 Semester : 2

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Students are suggested to review their knowledge on the following Bachelor subjects:
- Thermal Engineering: thermodynamic properties, internal combustion engines, heat transfer
- Fluid Mechanics: Navier-Stokes equations , subsonic/supersonic flows, waves and discontinuities
- Advanced Mathematics: solving of differential equations

OBJECTIVES

Understanding of and ability to solve problems and cases related to

- Fundamentals of a combustion processes: fuels, stoichiometry, thermochemistry, chemical kinetics, mass diffusion.
- Navier-Stokes equations for reacting mixtures: combustion source terms, dimensionless numbers, energy equations.
- Simple reacting systems: global combustors, well-stirred reactors.
- Convection and diffusion of mass and heat.
- Structure and properties of premixed flames.
- Combustion fronts: deflagrations and detonations.
- Structure and properties of non-premixed (i.e. diffusion) flames.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Combustion fundamentals.
Thermodynamics of mixtures. Reactions and species in combustion processes.
Major and minor species. Global reaction mechanism.
Non-stoichiometric mixtures. Flame temperature and fuel specific energy.
Chemical kinetics: global reaction rate.

2. Navier-Stokes equations of reacting mixtures.
Length and time scales. Mass conservation and diffusion; Fick's law.
Momentum equation. Energy equation: enthalpy and temperature forms; combustion heat rate.
Dimensionless parameters. Application to simple combustors.
A purely diffusive application: liquid droplet evaporation.

3. Premixed flames.
Introduction. The heating/burning/post-burning region structure.
Planar 1D model with constant coefficients.
Solution of the heating and burning regions.
Flame velocity, temperature, and thickness.
Anchored flames.
Influence of main parameters. Flammability range.
Flame cooling and quenching in a tube. Ignition.

4. Combustion fronts.
Jump conditions across reacting fronts.
The Raleigh and Hugoniot curves.
Deflagrations and detonations.
Chapman-Jouguet fronts.
Deflagrations in open and semi-closed tubes.

The double ZND structure of a detonation.
Combustion fronts in practice.

5. Non-premixed flames.
Introduction. Flame configurations.
The fuel/burning/air region structure. Fuel aeration
Spherical 1D model with constant coefficients.
Determination of the flame length and temperature.
Introduction to a jet flame model: the conserved scalars.
Influence of main parameters; empirical correlations.
Droplet burning. 1D vaporization-controlled spray combustion.

6. Introduction to advanced topics and experimentation.
Radiation. Turbulence.
Visualization of different flame regimes.
Experimental diagnosis of flames.

LEARNING ACTIVITIES AND METHODOLOGY

The methodology combines
1) lecture classes presenting the different subjects
2) exercise and problem solving sessions
3) laborotary sessions
4) homework assignements
5) several quizzes

Tutorials can be both personally or through Aula Global

ASSESSMENT SYSTEM

In order to pass the subject in the ordinary call, two requirements need to be met:
1) to have a MINIMUM mark of 4.0 over 10 in the end-of-term exam;
2) to have a minimum overall mark of 5.0 over 10 (weighing 60% the end-of-term exam mark and 40% the mark of the continuous evaluation).

% end-of-term-examination:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

BASIC BIBLIOGRAPHY

- GLASSMAN Combustion, 4th edition, Elsevier, 2008
- TURNS An introduction to combustion concepts and applications, 3rd edition, McGraw Hill, 2012

ADDITIONAL BIBLIOGRAPHY

- F. WILLIAMS COMBUSTION THEORY, PERSEUS BOOKS, 1985