Explosive Dynamics

Academic Year: (2023 / 2024) **Review date: 03-10-2023**

Department assigned to the subject: Thermal and Fluids Engineering Department

Coordinating teacher: VERA COELLO, MARCOS

Type: Compulsory ECTS Credits : 3.0

Year : 3 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

To take this course the student must have previously taken the subjects scheduled for the first two courses with basic contents of Physics, Chemistry and Mathematics.

OBJECTIVES

- Understand the nature of explosive processes, the effects generated by an explosion and the concept of TNT equivalent.
- Know the different types of explosives, their history and applications (both civil and military).
- Acquire capabilities of estimation and calculation of thermochemical properties of pure explosives and explosive mixtures.
- Know the composition, properties and equations of state that define the behavior of air as an ideal gas.
- Know the fundamental principles of compressible flow dynamics, their conservation equations and the most relevant dimensionless numbers.
- Understand the different types of waves that are generated in explosive processes, the associated pressure fields and their interaction with geometry.
- Acquire shock wave estimation and calculation capabilities including the elementary use of dimensional analysis concepts, and the exact solution of equations in simple cases.
- Know the various theories that allow estimating other effects of explosions, such as crater formation, projection of fragments or effects on people, applying them to specific examples.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Introduction to explosive processes

- What is an explosion?
- Energy release: TNT Equivalent
- Types of explosions

2. Explosives

- Historical Introduction
- Classification of explosives
- Properties
- Applications

3. Thermochemistry of explosions

- Chemical composition of explosives
- Oxygen balance
- Nominal explosion products
- Application examples: TNT, PETN, etc.
- Explosive strength: The Berthelot approximation
- Speed of the projected fragments: The Gurney analysis
- Explosive mixtures

4. Properties of air

- Composition
- The air as an ideal gas: Equations of state
- Speed of sound

- Isentropic processes
- Stagnation properties

5. Shock waves

- Normal shock waves
- Reflection at normal incidence
- Oblique shock waves
- Reflection of shock waves at oblique incidence
- Mach reflection, or Mach stem regime

6. Blast waves

- Parameters that characterize the shock wave
- Scaling laws for shock waves
- Practical applications

7. Effects of explosions

- Effects of explosions on the human body
- Effects of explosions on structural elements
- Crater formation
- Fragment projection
- SiMex toolbox

LEARNING ACTIVITIES AND METHODOLOGY

The learning methodology includes classroom activities with teacher support and non-contact included.
- Taught ECTS: 1.2 credits of the subject correspond to student work with teacher support (lectures, solving problem classes in small groups, laboratory classes, student presentations).
- Non-contact ECTS: 1.8 credits of the subject are personal student work (including research, writing papers, tests and examinations, etc.).

50% of the training activities are aimed at the acquisition of theoretical knowledge. The remaining 50% is aimed at the acquisition of practical skills related to the program.

ASSESSMENT SYSTEM

The evaluation system includes the continuous assessment of student work (papers, reports of laboratory tests and evaluation of skills and theoretical and practical knowledge) and the final evaluation through a final written exam that will assess the global knowledge of the subject, skills and abilities acquired throughout the course. Assigned percentages are 42% (continuous assessment) and 58% (written exam (42%) and computer lab report (16%)).

% end-of-term-examination:	58
% of continuous assessment (assigments, laboratory, practicals…):	42

BASIC BIBLIOGRAPHY

- Jacqueline Akhavan The chemistry of explosives, Royal Society of Chemistry (RSC) Publishing, 2011
- G.F. Kinney, K.J. Graham Explosive Shocks in Air (2nd Ed.), Springer-Verlag, 1985
- J.P. Agrawal High Energy Materials, Wiley-VCH, 2010
- M. Vera Dinámica de explosiones, UC3M, 2015
- P.W. Cooper Explosives Engineering, Wiley-VCH, 1996

ADDITIONAL BIBLIOGRAPHY

- C.E. Needham Blast Wave Propagation, Springer-Verlag, 2010
- S. Glasstone, P.J. Dolan The Effects of Nuclear Weapons, U.S. Department of Defense, 1977
- Technical Manual TM 9-1300-214 Military Explosives, Department of the Army, 1990
- Unified Facilities Criteria (UFC) 3-340-02 Structures to resist the effects of accidental explosions, U.S. Department of Defense, 2008

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- A. Pennardt, E.J. Lavonas . Blast Injuries: http://emedicine.medscape.com/article/822587-overview

- Department of the Army Technical Manual TM 9-1300-214 . Military Explosives: archive.org/details/milmanual-tm-9-1300-214-military-explosives

- S. Glasstone, P.J. Dolan . The Effects of Nuclear Weapons: http://www.deepspace.ucsb.edu/wp-content/uploads/2013/01/Effects-of-Nuclear-Weapons-1977-3rd-edition-complete.pdf