Rosetta Forum - Course Catalog
PIONEER SEMINAR #2

火箭推進的發展 - 當代燃燒概論
Advancements in Rocket Propulsion: Exploring Contemporary Combustion Theories

Oct. 21, 2024 (Monday) 7:30 P.M. ~ 9:30 P.M.
Oct. 23, 2024 (Wednesday) 7:00 P.M. ~ 9:30 P.M.

ASSIGNEE: Y.C. Chao Ph. D, APL Faculty Advisor

APPROVED BY: Aaron Wu, President of AEAS

STATUS: Released

SECURITY: PB

1. Scope of the Course

To facilitate the participants with the required background and theoretical fundamentals to understand the combustion phenomena and combustion science and engineering. including: combustion thermodynamics, physics, and chemistry, phenomena and theory of premixed and non-premixed flames, ignition, flame stabilization, turbulent flames, droplet and spray combustion, and high-speed combustion etc.

2. Course Description

The course will include:

- Review of Thermodynamics of Combustion Processes, Transport Phenomena, and Chemical Kinetics and Reaction Mechanism.
- Mathematical Description of Flames including Conservation Equations for Multi-component Reacting gas Flows.
- Combustion physics, chemistry, phenomena, and theory of premixed, non-premixed (diffusion) flames, ignition, flame stabilization, turbulent flames, droplet and spray combustion, high-speed combustion, etc.
- Combustion phenomena and theories as applied to hybrid combustion propulsion.

3. Target Audience

The course will benefit both students who work with propulsion engineering in the research team and new engineers to the team.

- Students have previously taken Intro to Chemistry, Thermodynamics, and Fluid Mechanics courses who want to understand more about combustion as applied to rocket propulsion, especially to hybrid rockets.
- Engineers interested in the propulsion system, development, manufacture, and testing.
- System engineers who develop requirements for systems that incorporate the use of thermodynamics and propulsion performance.

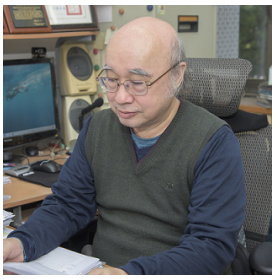
4. What You Will Learn

- Laws of Thermodynamic
- Molecular Transport Phenomena and Processes
- Chemical Kinetics and Reaction Mechanism and Chemical Stoichiometry
- Premixed and Diffusion Flames
- Flame Dynamics and Flame Stabilization
- Hybrid Rocket Propulsion

5. Course Outline

- Introduction: Fundamental Definitions and Phenomena, Experimental and Numerical Tools.
- Review: Thermodynamics of Combustion Processes, Transport Phenomena, Chemical Kinetics and Reaction Mechanism
- Mathematical Description of Flames: Conservation Equations for Multi-component Reacting Gas Flows
- Laminar Premixed Flames and Laminar Non-premixed (Diffusion) Flames
- Ignition Processes and Flame Stabilization
- Hybrid Rocket Combustion

6. Instructor



Professor Chao, Yei-Chin is a Chair Professor in the Department of Aeronautics and Astronautics Engineering at National Cheng Kung University. He obtained his Ph.D. from the School of Aerospace Engineering at the Georgia Institute of Technology in 1984. He has served as the Head of the DAA at NCKU, a Springer Visiting Professor in the Department of Mechanical Engineering at UC Berkeley, and the President of the Combustion Society of the Republic of China.

Professor Chao's research team developed catalytic technology and successfully created a complete H2O2 monopropellant thruster for space-grade reaction control systems (RCS). This technology has been applied to the TRITON Satellite, FORMOSAT-7, and subsequent satellite missions.

Since 2010, Professor Chao's research team has continuously developed comprehensive rocket systems for N_2O hybrid rockets, including combustion chamber design and ignition system testing. The team successfully launched hybrid rockets in 2011, 2015, 2019, and 2022, with thrust levels growing from 300 kgf to 3000 kgf, leading among university teams in Asia.

Throughout his over 40-year career in rocket research, Professor Chao has published numerous theoretical and innovative papers on high-precision propulsion systems for national defense, micro-propulsion systems and micro-flames, flame dynamic instability, and stabilization mechanisms.

1. 課程宗旨

旨在為學員提供必要的知識背景和理論基礎，以理解燃燒現象和燃燒科學與工程，包括：燃燒熱力學、物理學和化學、預混合和非預混合火焰的現象與理論、點火、火焰穩定、湍流火焰、液滴和噴霧燃燒、以及高速燃燒等。

2. 課程概述

本課程將包括：

- 燃燒過程熱力學、傳播、化學動力學以及反應機制。
- 火焰的數學描述，包括多組分反應氣體流動的守恒方程。
- 燃燒物理學、化學、現象和理論，包括預混合和非預混合（擴散）火焰、點火、火焰穩定、湍流火焰、液滴和噴霧燃燒、以及高速燃燒等。
- 將燃燒現象和理論應用於混合燃燒推進。

3. 目標受眾

本課程將有益於研究團隊中從事推進工程的學生以及新加入該團隊的工程師。

- 之前修過化學、熱力學和流體力學導論課程，並希望更深入了解與火箭推進相關的燃燒的學生，特別是混合火箭方面的學生。
- 對推進系統、開發、製造和測試感興趣的工程師。
- 制定涉及熱力學和推進性能的系統要求的工程師

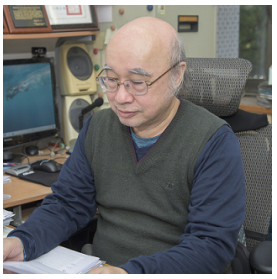
4. 你會學到

- 熱力學定律
- 分子傳輸現象和過程
- 化學動力學和反應機制以及化學計量
- 預混合和擴散火焰
- 火焰動力學和火焰穩定
- 混合火箭推進

5. 課程大綱

- 介紹：基本定義和現象、實驗和數值工具
- 複習：燃燒過程的熱力學、傳輸現象、化學動力學和反應機制
- 火焰的數學描述：多組分反應氣體流動的守恒方程
- 層流預混合火焰和層流非預混合（擴散）火焰
- 點火過程和火焰穩定
- 混合火箭燃燒

6. 講師



Chao, Y.C. 趙怡欽 教授 現為成功大學航太系講座教授，於1984年在美國喬治亞理工學院的航太工程研究所獲得博士學位，並曾擔任成大航太系主任、美國加州大學柏克萊分校機械系Springer訪問教授、中華民國燃燒協會理事長。

趙教授在太空推進系統的自主發展方面有著卓越的貢獻，趙教授團隊發展出觸媒提煉技術，並成功打造完整的太空用反應控制系統 (RCS) 的過氧化氫單基推進器。於2013年國家探空火箭八號計畫完成系統整合與高空性能測試後，已應用於獵風者衛星、福衛七號以及後續衛星系統。

自2010年起，趙教授研究團隊持續進行過氧化亞氮 (N_2O) 混合火箭全火箭系統研發，包括燃燒室設計、點火系統設計測試等。團隊於2011、2015、2019與2022年成功發射大型混合火箭，推力從300公斤成長到3000公斤等級，領先亞洲各大學團隊。

在超過40年的火箭研究生涯中，趙教授還在國防高精準推進系統、微動力系統與微火焰、火焰動態不穩定與穩駐機構等多個研究主題，發表多篇理論與創見。