


FUNDAMENTALS OF COMBUSTION FOR PROPULSION

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PRE-REQUISITES : UG/PG degree in Mechanical/Aerospace Engineering

INTENDED AUDIENCE : Research students working in the area of combustion and propulsion, Practicing engineers in the area of development of combustion and propulsion systems for space and defense applications

INDUSTRIES APPLICABLE TO : DRDO, ISRO, HAL, NAL

COURSE OUTLINE :

The gulf between science of combustion and its practice is strikingly visible during interactions between academics and practitioners. In spite of this, significant progress has happened over the last few decades in development of propulsion systems for space and defense applications in India. But in dealing with 'combustion instability', practitioners find the existing methods of practice and more importantly the way of thinking highly inadequate. This course, in an interactive way, will attempt to bridge this gap by introducing practitioners and research scholars in the field of combustion and propulsion to essential existing ideas and a few new ones. It is hoped that this will enable the participants to think of novel strategies to deal with development of propulsion systems prone to 'instability'. The instructors also hope to learn of issues of fundamental nature that are required to address developments in practice.

ABOUT INSTRUCTOR :

Prof. S Varunkumar holds a BTech in Mechanical Engineering from NIT, Trichy (2007), and Ph. D in Engineering sciences from Indian Institute of Science, Bangalore(2013). He worked at IIT, Ropar for a brief period of 7 months and is currently working as an Assistant Professor in the Department of Mechanical Engineering at IIT Madras. He teaches undergraduate thermodynamics and graduate level course in numerical methods for thermal engineering, combustion and rocket propulsion. His research interests include, instability in solid propellant rockets and thermo-chemical conversion of lingo-cellulosic biomass and coal. His published work of significance in peer journals includes modeling of solid propellant combustion and lingo-cellulosic fuels. He is a participant in technical committees of ISRO and DRDO.

Prof. H S Mukunda was educated at the Mysore University (Bachelor degree in 1963 in Mechanical engineering) and Indian Institute of Science (Masters degree in Aeronautial engineering in 1965 and Ph. D in engineering sciences in 1970) served on the faculty at the Aerospace Engineering Department, Indian Institute of Science for 34 years. He taught and did research in combustion sciences for aerospace vehicles and missiles and other industrial biomass and fossil fuel based combustion devices. He has supervised over twenty-five doctoral theses, about four dozen Masters theses and developed several courses in Aerospace Engineering. He has published extensively on thermo-chemical conversion and written several books Understanding Combustion (second edition) and Understanding Aerospace Chemical Propulsion, and Understanding clean conversion of biomass to energy and fuels and Understanding Aerospace Vehicles. He has participated in the development process of major launch vehicles of ISRO and missiles of DRDO through review committees and troubleshooting several technical glitches and continues to be a participant in technical committees of ISRO and DRDO.

COURSE PLAN:

Week 1 : Lecture 1 – Equilibrium: physical, thermodynamic and chemical
Lecture 2 – Equilibrium controlled and rate controlled processes in gaseous, liquid and solid fuels
Lecture 3 – Calculation of equilibrium states

Week 2 : Lecture 4 – Laminar premixed and diffusion flames: principal features and differences
Lecture 5 – Quenching, flammability and other limit phenomena
Lecture 6 – Discussion of burning behavior of gaseous, liquid and solid fuels

Week 3 : Lecture 7 – Basics of composite solid propellant deflagration
Lecture 8 – Why model deflagration of composite propellants?
Lecture 9 – Statistical representation of composite propellants in HeQu1D – geometry and thermochemistry

Week 4 : Lecture 10 – Idea of lateral diffusion
Lecture 11 – Overview of the HeQu1D software and demonstration
Lecture 12 – Effect of aluminum

Week 5 : Lecture 13 – Erosive burning
Lecture 14 – Instability in solid rockets – 1
Lecture 15 – Instability in solid rockets – 2

Week 6 : Lecture 16 – Principal ideas of combustion in liquid propellant rockets
Lecture 17 - Principal ideas of combustion in gas turbine afterburners
Lecture 18 – Combustion in boundary layers and hybrid rockets – essential ideas and emerging trends

Week 7 : Lecture 19 – Instability in liquid propellant rockets and gas turbine afterburners– modes and mechanism
Lecture 20 – Strategies for evolving instability free designs – global and local considerations
Lecture 21 – Is there a connection between instability in LPP gas turbine primary combustors and rockets/afterburners?

Week 8 : Lecture 22 – Discussion 1
Lecture 23 – Discussion 2
Lecture 24 – Overview of topics covered, topic not covered and what next?