

# Rocket Propulsion Elements

George P. SUTTON, Oscar BIBLARZ

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This book is addressed to researchers from the field of Aerospace Sciences and Aerospace Engineering. It constitutes a worthwhile completion of the curricula knowledge for the graduates of Aerospace Engineering and can be successfully recommended for postgraduate and advanced studies.

This book proves to be a valuable tool for the research and development activity, due to its structure and well-documented, organized information presented; the gradual approach focuses on designing and testing.

This 8<sup>th</sup> edition represents an enhanced updated version, that covers specific topics like: a)- fundamentals of rocket propulsion, essential technologies and master key designs; b)- various types of rocket propulsion systems, physical phenomena and basic equations; c)- advances in the field, such as: changes in materials, systems design, propellants, applications, manufacturing technologies, turbo-pumps; d)- liquid propellant rocket engines, solid propellant rocket motors, hybrid rockets and electrical space propulsion.

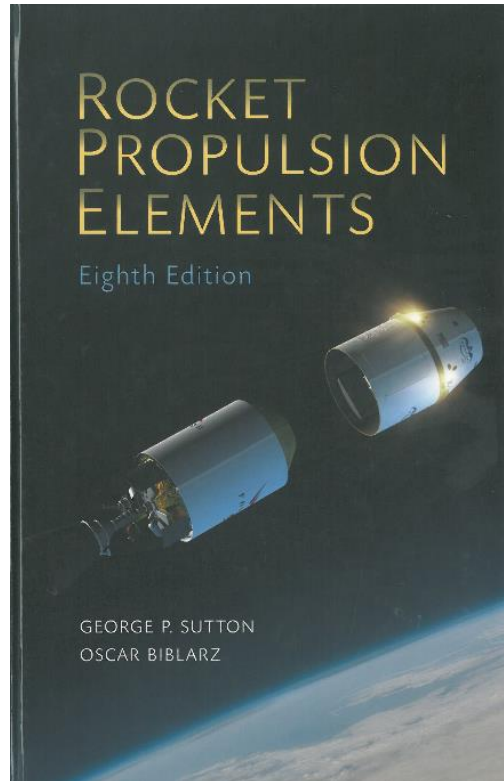
The information is structured within 20 chapters of a more than 765 A4 pages volume.

In its first 3 chapters the book presents the basics of the reactive propulsion.

**Chapter 1** introduces a classification of the reactive propulsion (i.e. duct jet propulsion and rocket propulsion) and some of its applications, such as space launch vehicles and spacecraft.

**Chapter 2** shows the definitions, fundamentals of propulsion and typical performance parameters (thrust, specific impulse, effective exhaust velocity and/ or nozzle exit velocity, mass flow rate and energy efficiencies).

**Chapter 3** deals with the nozzle theory; the concept of ideal rocket propulsion systems, the study of flow through nozzles (isentropic flow and real flow cases), alignment and configuration of nozzles, preparation for the study of variable thrust; performance analysis of a rocket propulsion system.



**Chapter 4** is dedicated to the study of flight performances; there are analyzed: the gravity free drag - free space flight, the forces acting on a vehicle in the atmosphere, the effect of the propulsion system on the performances, the aerodynamic effect of exhaust plumes, as well as the space flight, flight maneuvers, flight stability for both flight vehicles and military missiles.

In **Chapter 5** the performance analyzes for the chemical rocket propellant are exposed; the basic theory is introduced and relevant investigations are carried on (topics like the chamber or motor case condition, nozzle expanses processes have been thoroughly presented) followed by computer analysis and results of thermo-chemical calculations.

**Chapter 6** thoroughly details the basics of liquid propellant rocket engines; the topics covered are about propellants, propellant feed system, propellant tanks and their pressurization, turbo-pump feed system and engine cycles, rocket engines for maneuvering orbit adjustment, valves and pipelines, engine support structure.

**Chapter 7** presents the liquid propellants, the following issues being analyzed: propellant properties, liquid oxidizers, liquid fuels, liquid monopropellants, gelled versus gaseous propellants; safety measures in order to prevent hazards and environment damage are also discussed.

**Chapter 8** is dedicated to the key subassembly of the rocket engine, which is the thrust chamber. The injectors, the role of combustion chambers and nozzles in thrust generation, the heat transfer, starting and ignition and the variable thrust have been considered; a design analysis for a sample thrust chamber was drawn, in order to set the design steps.

The combustion of liquid propellants is exposed within **Chapter 9**, the instabilities being highlighted.

**Chapter 10** thoroughly details the turbo-pumps, the performances of multiple rocket propulsion system, propellant budget, the engine design, controls, calibration, integration and optimization.

Within **Chapter 11** the solid propellant rocket fundamentals are presented, with emphasis on the propellant burning rate, propellant grain and grain configuration, propellant grain stress and strain, and attitude control and side maneuvers with solid rocket motors.

**Chapter 12** provides details about the solid propellants, such as: their classification and characteristics, hazards, propellant ingredients, liners, insulators and inhibitors, propellant processing and manufacture.

The combustion of the solid propellants is discussed in **Chapter 13**; topics like physical and chemical processes, ignition process, extinction or thrust termination and combustion instability are covered.

Inside **Chapter 14** one can find useful design aspects regarding solid rocket components and motor, such as: nozzle, motor case and ignition hardware.

The design process is completed by the relevant topics presented within the last 5 chapters, as follows: Hybrid propellant rockets - **Chapter 15**, Thrust Vector Control, for the single nozzle and multiple chamber and multiple nozzles - **Chapter 16**, a selection of rocket propulsion systems can be found in **Chapter 17**, Rocket exhaust plumes, including mathematical simulation of flow around such bodies - **Chapter 18**; The electric propulsion studied in **Chapter 19** provides information regarding the flight performances for the ideal case, electro-thermal versus non-thermal electric thrusters, optimum flight performance, mission applications, electric space-power supplies and power conditioning systems.

Significant information on rocket testing is grouped in **Chapter 20**; types of tests, test facilities and safeguards, instrumentation and data management, flight testing and post-accident procedures are detailed.

For each chapter significant applications are proposed and references lists are specified. Additional information provided in Appendices 1 up to 5 is useful, as: Conversion Factors and Constants, Properties of the Earth's Standard Atmosphere (up to 1000 km), Key equations for ideal chemical rockets.

Both authors are highly skilled professionals of aerospace industry; George Sutton former executive director of engineering at Rocketdyne (Pratt & Whitney Rocketdyne) and Oscar Biblarz - Professor Emeritus in the Department of Mechanical and Astronautical Engineering at the Naval Postgraduate School in Monterey, California.

Review and presentation:

Dr. Eng. Irina ANDREI,

INCAS – National Institute for Aerospace Research “Elie Carafoli”

Flow Physics Department/ Numerical Simulation Unit

B-dul Iuliu Maniu 220, Bucharest 061126, Romania

e-mail: andrei.irina@incas.ro