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INTEGRATED INTERNAL AND EXTERNAL BALLISTICS FOR SOUNDING ROCKET DESIGN

Abstract

This paper reports integrated internal and external ballistics for a sounding rocket, particularly useful for its design process to meet a target altitude requirement. Sounding rockets have been utilised since the 1950s for various missions including mandatory atmospheric inspection, aerodynamics tests, supersonic combustion tests, etc. Today, it is also a useful measure as CanSat/CubeSat carrier, and there are numerous university-based sounding rockets not only for an educational purpose on sounding rocket system itself but also for operation of CanSats launched by a sounding rocket. It is obvious that one of the key performance parameters of a sounding rocket operation is its peak altitude, as its mission is determined considering how high altitude it reaches. While meeting peak altitude requirements, another aspect that has attracted interest is economy of the flight, which has been recently reflected on reusable rockets as well as small scale sounding rockets. In light of these aspects, maximisation of peak altitude for economical operation is an essential part of design consideration. In this study, a single stage sounding rocket has been considered to investigate the effect of the design inputs of a propulsion subsystem on its flight performance. For this purpose, integrated internal and external ballistics has been considered and an integrated code has been developed. Propulsion system design and performance parameters such as propellant flow rate, burn time, chamber pressure, propellant specific impulse, and more have been considered as inputs for the integrated ballistics and their effect on the flight performance has been investigated. The results say that for each thrust amount to be produced, having more propellant loaded on a sounding rocket does not necessarily mean it reaches higher altitude, and particularly for a single stage sounding rocket with a blowdown feeding system, due to propellant flow variation affected by feeding pressure that is also varying, there is an optimum propellant volume to be filled in a tank in order to maximise the peak altitude of a sounding rocket.