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Solid and Hybrid Propulsion (1) (3)

Author: Dr. Francesco Barato  
University of Padova - DII/CISAS, Italy, francesco.barato@unipd.it

Dr. Elena Toson  
T4i, Italy, e.toson@t4innovation.com  
Prof. Daniele Pavarin  
T4i, Italy, d.pavarin@t4innovation.com  
Mr. enrico paccagnella  
Università degli Studi di Padova, Italy, paccagnella.enrico@gmail.com  
Dr. alessandro ruffin  
T4i, Italy, a.ruffin@t4innovation.com

VARIATIONS AND CONTROL OF THRUST AND MIXTURE RATIO IN HYBRID ROCKET  
MOTORS**Abstract**

Hybrid rockets motors have several attracting characteristics like simplicity, low cost, safety, reliability, environmental friendliness. In particular, hybrid rockets can provide complex and flexible thrust profiles not possible with solid rockets in a simpler way than liquid rockets, controlling only a single fluid. Unfortunately, the drawback of this feature is that the mixture ratio cannot be directly controlled but depends on the specific regression rate law. Therefore, in the general case the mixture ratio changes with time and with throttling. Thrust could also change with time for a fixed oxidizer flow. Moreover, propellant residuals are generated by the mixture ratio shift if the throttling profile is not known in advance. The penalties incurred could be more or less significant depending on the mission profile and requirements. In this paper, some proposed ways to mitigate or eliminate these issues are recalled, quantitatively analyzed and compared with the standard case. In particular, the addition of energetic additives to influence the regression rate law, the injection of oxidizer in the post-chamber and the altering-intensity swirling-oxidizer-flow injection are discussed. The first option exploits the pressure dependency of the fuel regression to mitigate the shift during throttling. The other two techniques can control both the mixture ratio and thrust (at least in a certain range) at the expense of an increase of the architecture complexity. Moreover, some other options like pulse width modulation or multi-chamber configuration are also presented. Finally, a review of the techniques to achieve high throttling ratios keeping motor stability and efficiency is also discussed.