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SPACE PROPULSION SYMPOSIUM (C4)
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# EVALUATIONS OF DATA REDUCTION METHODS FOR HYBRID ROCKETS

**Abstract**

Data reduction from hybrid rocket firings presents unique challenges comparing with other types of chemical rockets. A typical hybrid rocket employs a combination of solid fuel and liquid oxidizer. Although the flow rate of the liquid oxidizer is directly measurable, it is not for the solid fuel. Because the characteristic exhaust velocity (c*) strongly depends on oxidizer to fuel ratio (O/F), the direct calculation of the flow rate from chamber pressure and nozzle throat area like a solid rocket case, in which O/F is a known value, is not possible. Some researchers have developed various reconstruction techniques to obtain fuel consumption rate from measurable data such as chamber pressure and oxidizer flow rate. In this research, four kinds of data reduction methods were applied to 10 kN and 2.5 kN thrust class hybrid rockets to evaluate accuracies and applicable ranges of the methods. The first one (DRM-1) determines the fuel consumption rate as a function of time from histories of the chamber pressure and the oxidizer flow rate, assuming a constant c* during firing. This assumption is unrealistic because the c* variation due to the O/F shift during firing is not an uncommon feature in hybrid rockets. Other three methods obtain O/F by solving an equation between theoretical and experimental c* values without assuming constant c*. The second one (DRM-2) uses histories of chamber pressure and oxidizer flow rate, assuming constant c* efficiency. The third and fourth one (DRM-3 and DRM-4) eliminates the need for the assumption of a constant c* efficiency by employing a thrust history as an additional input data. The difference between the two methods is that DRM-3 assumes a constant nozzle discharge coefficient whereas DRM-4 assumes constant thrust efficiency. From DRM-2 to DRM-4, a difficulty arises when multiple solutions of O/F exists in the equation between theoretical and experimental c* values. Three kinds of fuels (polyethylene, polystyrene, and PMMA) were examined and two of them (polyethylene and PMMA) showed this difficulty in a certain O/F range. In this case, DRM-1 is the most reliable. Like this, which one is the most reliable depends on the condition of a firing test such as propellant combination, O/F range in the firing, and the accuracy of thrust data. Some specific discussions are presented in this paper by adopting the four data reduction methods to several typical static firing test data.