Modeling Mass Flow Distribution in a Multistage Rocket Concept Design

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The center of gravity of a rocket is imperative to the stability of the rocket during its flight. To remain stable over the course of a flight or a burn, the center of gravity of a mid-scale rocket is generally accepted to be stable if it is located at least 1 body diameter forward of the center of pressure. This relationship becomes particularly important when the center of gravity is varying in unexpected ways during the flight. Such is the case with the multistage rocket concept that was proposed that had, in its first stage, fluid, non-propellant mass being displaced from the forward end of the rocket while thrust-inducing propellant was naturally being ejected from the aft end of the rocket. This experiment utilized the displacement water from an oscillating balance, measuring the variable tangential acceleration in coordination with relative mass distribution of the balance to demonstrate the uniquely variable nature of the stage's center of gravity. Overall, a rapid, initial shift forward was observed, but was quickly reversed by a shift aft, from which the center of gravity then gradually shifted back to its natural geometric location for the rest of the flight. Such oscillations are necessary to consider for flight stabilizer design, and the results of the simulation suggested that a center of pressure that is significantly aft is best to enhance the first stage's stability.