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DEVELOPMENT OF A DESKTOP HYBRID ROCKET MOTOR FOR CLASSROOM DEMONSTRATION

Abstract

This paper details the design of a static hybrid rocket motor, which can be safely fired within a classroom environment allowing close quarter observation of the combustion process. Combustion visibility is achieved by utilisation of a fuel grain manufactured from extruded acrylic (a transparent thermoplastic polymer) while nitrous oxide (N2O) has been selected as the oxidiser. The design is constrained in terms of both size and safety. Maximum fuel grain dimensions are restricted to [OD L] = [50 100] mm and a minimum FOS of 5 is applied to all combustion chamber components. Transient regression rate characteristics for the acrylic / N2O hybrid design have been obtained by applying an algorithm suggested by Humble (1995). The results obtained via this algorithm serve as a foundation for both FEA and thermal analyses. In addition, the data has been used to optimise the design, thereby establishing the ideal theoretical performance as follows: Isp = 217 s, Ft = 73 N and p0c = 26 bar. Substantiation for the results obtained during the FEA and thermal studies is presented via a combination of hand calculation and physical testing. Furthermore a selection of transient burn data from initial testing is presented and compared with the theoretical model in order to evaluate the accuracy of the simulation. Concerns surrounding Explosive Decomposition (ED) of the oxidiser, due to a phenomenon known as adiabatic compression, are addressed in detail and this includes a historical perspective. Furthermore, a detailed explanation of the preventative measures utilised in order to eliminate the risk of ED is also presented.