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# EFFECT OF DIFFERENT THERMAL CURE CYCLES ON THE PROPELLANT CURING OF SOLID ROCKET MOTOR: A NUMERICAL STUDY

**Abstract**

Thermal cure cycle plays a important role in realizing the defect free propellant grains of solid propellant rocket motors. Cure cycle is chosen for achieving decent curing in order to get the specified mechanical properties of propellant. Cure characteristics chiefly depends on the thermal response of propellant grain and the cure rate governed by Arrhenius equation. The focus of present numerical analysis is to study the effect of different thermal curing cycles on the transient thermal response and degree of cure in the propellant grain. Propellant curing process is a complex thermo-chemical phenomenon and the effect of generated heat on reaction is considered by coupling the heat transfer and chemical kinetics. A thermo-chemical mathematical model is developed where the heat diffusion and chemical-kinetic reactions and associated heat generation equations are solved simultaneously as a coupled system of equations. Non-linear transient finite element code is used to compute the temperature history in the axi-symmetric domain by considering non-linear thermo-physical properties (Specific heat, density and thermal conductivity) of motor case, insulation, propellant grain and mandrel. Runge-Kutta fourth order time stepping scheme is used for solving the ordinary differential equation for chemical kinetics (Arrhenius equation). The model is validated using the in house developed package (FEAST) with convective boundary condition on a thin web propellant grain without heat generation term. Radial temperature distribution obtained with in-house code is in good agreement with commercial package. The metallic casing, insulation, propellant and mandrel were modeled and transient heat transfer analysis is carried out for the different cure cycles. The four-node axi-symmetric quadrilateral element (finite element mesh) is used for the analysis. Initial temperature for the transient analysis is assumed to be 313K over the entire computational domain. Convective boundary condition is applied outside the motor metallic hardware as well as on the propellant grain port based on the convective heat transfer coefficients computed using the correlations based on turbulent flow in ducts and flow across cylinder respectively. Temperature and degree of cure contours, transient response curves of different locations are plotted at various time levels of different curing cycles for detailed analysis.