During ascent and reentry of a hypersonic space vehicle into the atmosphere of any heavenly body, the space vehicle is subjected, among others, to extreme aerothermic loads. Therefore an efficient, sophisticated and lightweight thermal protection system is determinant for the success of the entire mission. For a deeper understanding of the conductive, convective and radiative heating effects through a thermal protection system, a mathematical model is investigated which is given by an optimal control problem subject to not only the usual dynamic equations of motion and suitable control and state variable inequality constraints, but also to an instationary quasi-linear heat equation with nonlinear boundary conditions. By this model the temperature of the heat shield can be limited in certain critical regions.

The resulting ODE-PDE constrained optimal control problem is solved by a second-order semi-discretization in space of the quasi-linear parabolic partial differential equation yielding a large scale nonlinear ODE constrained optimal control problem with additional state constraints for the heat load. Numerical results are presented. The aerothermic load and the fuel loss due to engine cooling can be considerably reduced by optimization.

Finally, an academic example is given which reveals the complicated theoretical background of state-constrained ODE-PDE optimal control problems caused by their mutual impact.