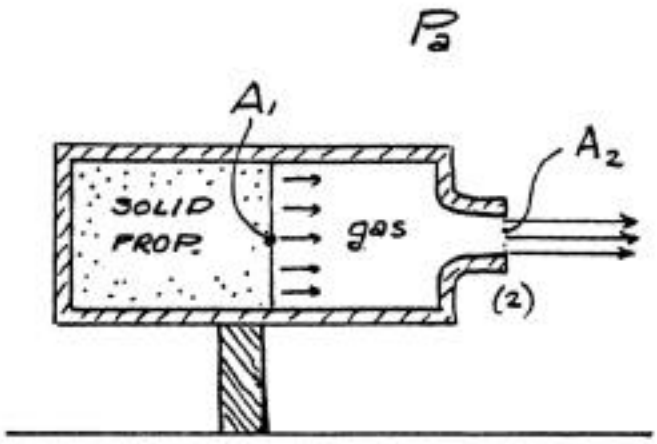
Problem 5.18

Rocket firing on test bed



The figure shows a rocket burning solid propellant, the system being mounted on a stationary test bed. The rocket body has an inside area A_1 where the fuel is, and tapers to a smaller area A_2 at the exit plane. The combustible solid propellant has a density ρ_f and burns at a constant rate $\dot{m}_f$ $kgm^{-2}s^{-1}$. The combusted gases leave the solid interface with a density $\rho_g < \rho_f$; the flow to the exit plane is essentially incompressible. (This is a good assumption only if Mach number at the exit is small.)

Given: $A_1, A_2, \dot{m}_f, \rho_f, \rho_g$.

(a) Derive an expression for the gas velocity V_e at the exit plane.

HINT ANSWER

(b) Derive an expression for the *leftward* thrust F_S exerted by the rocket on its support.

HINT ANSWER

(c) Assuming that the gas flow is inviscid and incompressible, obtain an expression for the gauge pressure in the gas region to the right of the solid propellant.

HINT ANSWER

(d) What is the compressive stress σ_s inside the solid propellant?

HINT ANSWER

(e) Your answers will show that all of the above quantities are zero when $\rho_g = \rho_f$. Explain.