

16.522 Space Propulsion Problem Set 4

Problem 1

The DSCS geosynchronous satellite requires 723 W of power to the payload. At end-of-life, the array generates 837 W, and the batteries can discharge at a 750 W rate, which leaves $837 + 750 - 723 = 864$ W available for electric propulsion for NSSK. This satellite uses for that purpose a superheated hydrazine thruster with a nozzle expansion ratio $A_e/A_t = 50$. The heating chamber is limited by materials to a maximum temperature of 2000 K. Calculate the specific impulse and the thrust obtainable from this engine. Estimate the fuel saved over 10 years by the electric heating. Assume hydrazine is fully decomposed to N_2 and H_2 , and use $\gamma = 1.33$, roughly valid for the expected throat temperature. Assume a thermal efficiency of 85% (i.e., 15% of the heating power is lost).

Problem 2

Consider superheated Hydrogen gas at $p = 1$ atm. We are interested in the ionization equilibrium of such hot gas. For $T > 4000^\circ\text{K}$, diatomic H_2 is not present anymore ($H_2 \rightarrow 2H$). So ionization is from atomic hydrogen, H, for which,

$$q_i = 1 \quad q_n = 2 \quad V_i = 13.6 \text{ V}$$

- (a) Demonstrate that, indeed, above about 4000°K , H_2 could be approximated as fully dissociated.
- (b) For the range $5000 < T < 16,000^\circ\text{K}$, calculate: n_e , n_n , the ionization fraction α , $\ln \Lambda$, ν_{ei} , ν_{en} , ν_{ei}/ν_e and the electric conductivity σ . Show your results as plots in the indicated temperature range.

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