AE 5335 is taught by Dr. Riggins

Final Exam

Propulsion 2

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1.0 Results

2.0 The required current in the ion-drive: 8.957679 Amp

3.0 The required voltage in the ion-drive: 235778.445 V

4.0 The acceleration distance (distance between the anode and cathode in the ion-drive): 2.35778 cm

5.0 The mass flow rate of propellant required for the ion-drive: $0.0035830716 \frac{kg}{s}$

6.0 The thrust provided by the ion-drive: 123.0247639 N

7.0 **The diameter of the (round) ion beam:** 0.4540291 m

8.0 The overall (total) electrical power required by the drive (including the ionizer): 3249.27231 kW

9.0 The required compressor pressure ratio and the temperature of the nitrogen gas at compressor entrance (radiator exit): $\pi_c = 2.64$, $T_a = 1472\ K$

10.0 The temperature of the nitrogen gas at exit of compressor and at the exit of the turbine (radiator entrance):

$$T_2 = 1994.80286196426\ K,$$

$$T_4 2345.999387383701\ K$$

11.0 The overall (total) power supplied by the turbine in the Brayton cycle: 16197.12063 kW

12.0 The power required by the compressor in the Brayton cycle:

11709.53794 kW

13.0 The heat rate required from the nuclear reactor:

$24894.9331103493\ kW$

14.0 The cycle (thermal) efficiency: $\eta = \ 0.130519423193357$

15.0 The radiator area required: $34.3726419963576\ m^2$

16.0 The mass flow rate of nitrogen gas required in the Brayton cycle:

$23.84117856 \frac{kg}{s}$

17.0 The accelerator efficiency (exhaust kinetic energy rate/total power needed by ion drive including ionizer):

$\eta_a = 0.65$

18.0 The total required engine mass:

$m_e = 5415.45385$ kg

19.0 The propellant mass used during the acceleration leg:

$$m_{p,A} = 51134.16711\ kg$$

20.0 The propellant mass used during the deceleration leg:

$m_{p,D} = 18450.54614\ kg$

21.0 The firing times for the ion-drive (acceleration and deceleration legs): $\tau_A = \frac{m_{p,D}}{\dot{m}_p} = \frac{51134.16711}{0.0035830716} = 14271042.51\ sec = 165.17\ days$

$$\tau_D = \frac{m_{p,A}}{\dot{m}_p} = \frac{18450.54614}{0.0035830716} = 5149365.74\ sec = 60\ days$$

22.0 The EXACT distance traveled during this mission from beginning to end (determine and give acceleration distance, cruise distance, deceleration distance, and total distance)

$$d_A = 35000\ m$$

$$d_C = 3.024e9\ m$$

$$d_D = 35000\ m$$

$$d_{total} = 3.02407e9 m$$

Code:

```
% main.m
clc
clear all
close all
format longg


T3 = 3000;
gam = 1.4;
etat = .9;
etac = etat;
sig = 5.67*10^-8;
eps = 1;

i = 1;
Table = zeros(700000,5);
A = zeros(700000,1);

for pic = 2:.01:3
    pit = 1/pic
    taut = 1-etat*(1-pit^((gam-1)/gam))
    T4 = T3*taut
    for Ta = 500:1700
        Table(i,1) = pic;
        Table(i,2) = Ta;
        T2 = (1+1/etac*(pic^((gam-1)/gam)-1))*Ta
        Table(i,3) = T2;
        eta = 1-(T4-Ta)/(T3-T2)
        Table(i,4) = eta;
        a = (1/eta-1)/(3*(T4-Ta)*sig*eps)*(1/Ta^3-1/T4^3)
        A(i,1) = a;
        Table(i,5) = a;
        i = i + 1
    end
end
m_dot = A
% Find row of smallest magnitude.  The value may be negative.
[smallestAbsValue, rowOfSmallestValue] = min(abs(m_dot))
% Get the actual value in case it's negative.
smallestValue = m_dot(rowOfSmallestValue)
% Find row of smallest positive number.
positiveIndexes = m_dot > 0;
[smallestPosValue, rowOfSmallestValue] = min(m_dot(positiveIndexes))
```