

**Problem 1**

M1	0.42
A2/A1	0.70676
A3/A2	1.1349
cp	0.24 Btu/lbm-F
1	32.17 lbm-ft/lbf-sec <sup>2</sup>
1	778 lbf-ft/Btu

$$T = T_0 - v^2/2c_p$$

$$M = V/c = V/(49.02 \cdot T^{0.5})$$

P1/P0	0.88572
T1/T0	0.96592
A1/A*	1.5289

$$A2/A^* = (A2/A1)(A1/A^*)$$

$$A2/A^* = 1.08057$$

$$P2/P0 = 0.70802 \quad B2:M2=0.72$$

$$P2/P1 = (P2/P0)/(P1/P0)$$

$$\mathbf{P2/P1 = 0.79937}$$

$$A3/A^* = (A3/A2)(A2/A^*)$$

$$A3/A^* = 1.2263$$

$$P3/P0 = 0.80224 \quad B2:M3=0.57$$

$$P3/P2 = (P3/P0)/(P2/P0)$$

$$\mathbf{P3/P2 = 1.1331}$$

P2	63 psi
A2	3.2 in <sup>2</sup>
T0	540 R
<b>M1</b>	<b>0.42</b>
<b>M2</b>	<b>0.72</b>
<b>M3</b>	<b>0.57</b>

$$P1 = P2/(P2/P1)$$

$$\mathbf{P1 = 78.81 \text{ psi}}$$

$$P0 = P2/(P2/P0)$$

$$P0 = 88.98 \text{ psi}$$

$$A^* = A2/(A2/A^*)$$

$$A^* = 2.9614 \text{ in}^2$$

$$m^* = 0.5317(A^*)(P0)/(T0)^{0.5}$$

$$\mathbf{m^* = 6.029 \text{ lbm/sec}}$$

**Problem 2**

Po	100 psi
To	540 R
Amin	3.1 in <sup>2</sup>

The maximum isentropic value for the mass flowrate is when Amin=A\*

$$m^* = 0.5317(Po)(A^*)/(To)^{0.5}$$

$$\mathbf{m\_dot = 7.093 \text{ lbm/sec}}$$

$$m\_dot = 3.5465 \text{ lbm/sec}$$

$$(PminAmin/PoA^*) = PminAmin / m^*(To)^{0.5}/0.5317$$

$$PA/PoA^* = 0.02 Pmin$$

At max flow rate

$$P/Po = 0.52828$$

$$P = 52.828 \text{ psi}$$

At the minimum area PA/PoA\* is a constant

$$A^* = 1.55 \text{ in}^2$$

$$A/A^* = 2$$

$$\mathbf{M = 0.306}$$

$$P/Po = 0.9371$$

$$\mathbf{P = 93.71 \text{ psi}}$$

$$T/To = 0.9816$$

$$\mathbf{T = 530.1 \text{ R}}$$

$$V = M*c$$

$$\mathbf{V = 345.3 \text{ ft/sec}}$$

**Problem 3**

$m^* 1$	1.913 lbm/sec
$m^* 2$	0.9565 lbm/sec
$T_0$	540 R

**Mode 1**

$p_1$	84.12 psi
$p_2$	78.07 psi
$p_3$	69.84 psi
$A_3$	1.04 in <sup>2</sup>

$$p_3 A_3 / P_0 A^* = p_A / m^* T_0^{0.5} / .5317$$

$$p_A / P_0 A^* = 0.868745$$

$$p_3 / p_0 = 0.75888$$

$$p_0 = 92.03 \text{ po}$$

$$A_3 / A^* = 1.1447$$

$$A^* = 0.908535 \text{ in}^2$$

$$p_1 / p_0 = 0.914046$$

$$A_1 / A^* = 1.7334$$

$$A_1 = 1.574855 \text{ in}^2$$

$$p_2 / p_0 = 0.848307$$

$$A_2 / A^* = 1.3583$$

$$A_2 = 1.234063 \text{ in}^2$$

**Mode 2**

$$p_{011} = 92.03 \text{ psi}$$

$$m^* = 0.9565 \text{ lbm/sec}$$

$$m^* = 0.5317(P_0)(A^*) / (T_0)^{0.5}$$

$$A^* = 0.453984 \text{ in}^2$$

$$A_1 / A^* = 3.468963$$

$$P_1 / P_0 = 0.9801$$

$$\mathbf{P1 = 90.20 \text{ psi}}$$

$$M_1 = 0.1699$$

$$A_2 / A^* = 2.718295$$

$$P_2 / P_0 = 0.9671$$

$$\mathbf{P2 = 89.00 \text{ psi}}$$

$$M_2 = 0.219$$

$$A_3 / A^* = 2.290828$$

$$P_3 / P_0 = 0.95291$$

$$\mathbf{P3 = 87.70 \text{ psi}}$$

$$M_3 = 0.263$$