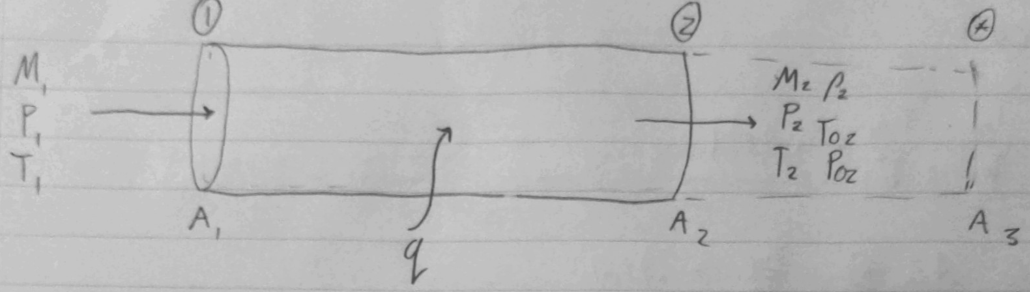
303
HW 3

1)


given: $M_1 = .4$
$P_1 = .8$ atm
$T_1 = 273$ K

find: M_2, ρ_2
P_2, T_{o2}
T_2, P_{o2}

gas: $\gamma = 1.4$
$R = 287 \frac{J}{kgK}$
$C_p = 1005 \frac{J}{kgK}$

assumptions: constant area
no friction
Caloric perfect gas

governing eqs: $q = c_p(\Delta T_o)$

Table A1 @ $M = .4$

$\frac{P_{01}}{P_1} = 1.1166$, $\frac{T_{01}}{T_1} = 1.0320$,

from ratios

$T_{01} = 281.7360$ K

$P_{01} = 0.8932$ atm

gov eq $\rightarrow$ $\frac{q}{c_p} + T_{o1} = \boxed{T_{o2} = 530.4922K}$

Table A3 @ $M = .4$

$\frac{P_1}{P^*} = 1.961$, $\frac{T_1}{T^*} = .6151$, $\frac{\rho_1}{\rho^*} = 3.188$, $\frac{P_{o1}}{P_o^*} = 1.157$, $\frac{T_{o1}}{T_o^*} = .5290$

from ratios

$P^* = .4080$, $T^* = 443.8303$, $\rho^* = .3245$, $P_o^* = .7720$

$\boxed{\begin{matrix}303\\ HW3\end{matrix}}$

problem 1 con't

$$\frac{T_{02}}{T_0^*} = \frac{T_{02}}{T_{01}} \frac{T_{01}}{T_0^*} = .9961$$

from table A3 @ $\frac{T_{02}}{T_0^*} = .9961$

$$\frac{P_2}{P^*} = 1.0874, \quad \frac{T_2}{T^*} = 1.0195, \quad \frac{\rho_2}{\rho^*} = 1.0666, \quad \frac{P_{02}}{P_0^*} = 1.0025, \quad \frac{T_{02}}{T_0^*} = .9961$$

$$\boxed{M_2 = .9285}$$

from ratios above

$$\boxed{P_2 = .4436 \text{ atm}, \quad T_2 = 452.4850\,K, \quad \rho_2 = .3461 \tfrac{kg}{m^3}, \quad T_{02} = 530.4922\,K, \quad P_{02} = .7740 \text{ atm}}$$

problem 2

problem 2 is Identical to problem 1 with different #'s. It has same assumptions etc. I decided to try a digitalized table for it and will attatch the code for that, however here are final answers

the tool box used is on matlab named compressible flow relati...

$M_2 = .2178$

$P_2 = 99.0241$ kPa

$T_2 = 349.8919$ K

$\rho_2 = .9891 \frac{kg}{m^3}$

$T_{02} = 352.1512$ K

$P_{02} = 102.3512$ kPa

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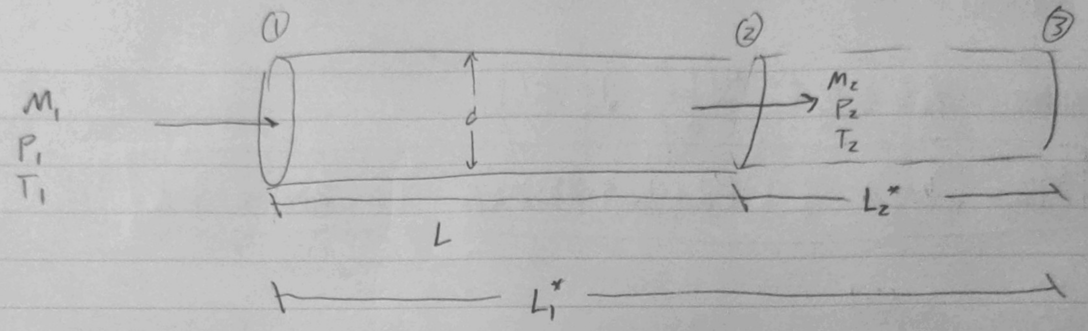
HW8

3)



given: $M_1 = .6$
$P_1 = 150e3\,Pa$
$T_1 = 300K$
$\bar{f} = .005$
$L = .45m$
$d = .03m$

find: M_2
P_2
T_2

assumptions: friction
calorically perfect gas
adiabatic

$\gamma = 1.4$
$R = 287 \frac{J}{kgK}$
$c_p = 1005 \frac{J}{kgK}$

gov. eq: $L_1^* - L_2^* = L$

$$\frac{4\bar{f}L_2^*}{d} = \frac{4\bar{f}L_1^*}{d} - \frac{4\bar{f}L}{d}$$

$\frac{4fL}{d} = .3$

from ideal gas $\rho_1 = 1.7422 \frac{kg}{m^3}$

from A.1 @ $M = .6$

$P_{01} = 191.3256\,kPa$, $\rho_{01} = 2.0729 \frac{kg}{m^3}$

from A3 @ $M = .6$

$P^* = 85.0647\,kPa$, $T^* = 268K$, $\rho^* = 1.1059$, $P_0^* = 161.0214$, $\frac{4fL_1^*}{d} = .4908$

from governing eq $\frac{4\bar{f}L_2^*}{d} = .1908$

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Problem 3 cont

from A3 @ $\frac{4\bar{f}L_2^*}{d} = .1908$

$\boxed{M_2 = .7093, \quad P_2 = 125.2332\ kPa, \quad T_2 = 292.2018\ K}$

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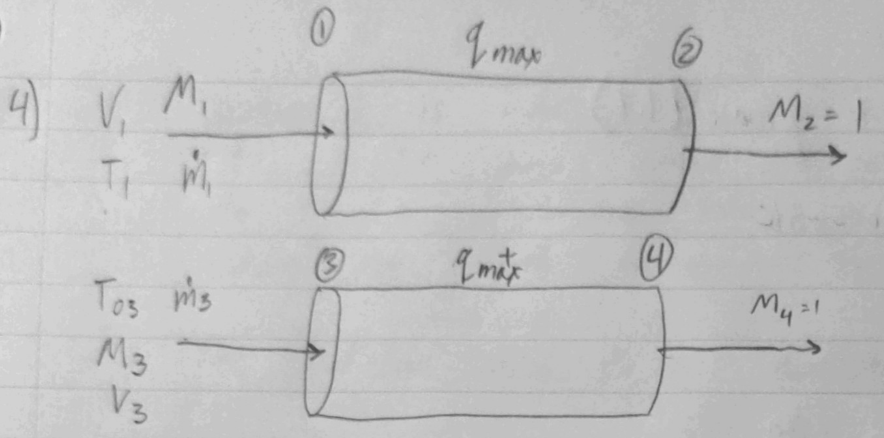
HW3

4)



$R = 287 \frac{J}{kgK}$
$c_p = 1005 \frac{J}{kgK}$
$\gamma = 1.4$

given: $V_1 = 100 \frac{m}{s}$
$T_1 = 400K$
$HV = 40e6 \frac{J}{kg}$

find: q_{max}
$\frac{\dot m_3}{\dot m_1}$

assumptions: uniform area
frictionless
neglect mass of fuel
calorically perfect

gov eq: ① $\dot q = \dot m_{air} C_p (\Delta T_0) = \dot m_{fuel} HV$
② $M = \frac{V}{a}$
③ $q = C_p(\Delta T_0)$
④ $a = \sqrt{\gamma R T}$

④ $a_1 = \sqrt{\gamma R T_1} = 400.8990 \frac{m}{s}$

② $M_1 = \frac{V_1}{a_1} = .2494$

from A1 @ M_1

$T_{01} = 404.9776K$

from A3 @ M_1

$T_{\cancel{x}} = 1.3190e3K$
$T_{0*} = 1.5828e3K$

from A3 @ $M_2 = 1$

$T_{02} = 1.5828e3K$

from gov eq ③

$$\boxed{q_{max} = C_p(T_{02} - T_{01}) = 1.1837e6\ J}$$

from gov eq ①

$\dot m_{air} = \frac{\dot q}{c_p \Delta T_0}$, $\dot m_{fuel} = \frac{q}{HV}$

$$\boxed{\left(\frac{\dot m_{fuel}}{\dot m_{air}}\right)_{max} = \frac{c_p \Delta T}{HV} = .0296}$$

based on new $q = q_{max}$ (1.1)

$T_{0}^{*} = \frac{q}{c_p} + T_{01} = 1.700603K$

$\frac{T_0}{T_0^*} = .2381$

from table A3 @ $\frac{T_0}{T_0^*}$

$M_3 = .2392$

$T_3 = 400.3951K$

$a_3 = 401.0969 \frac{m}{s}$

$V_3 = \frac{M_3}{a_3} = 95.9489 \frac{m}{s}$

$\frac{\dot{m}_3}{\dot{m}_1} = \frac{\rho_3}{\rho_1} \frac{A_3}{A_1} \frac{V_3}{V_1}$, $A_3 = A_1$

$\boxed{\frac{\dot{m}_3}{\dot{m}_1} = .9619 \text{ or } \%3.8 \text{ less than } q_{max}}$

Problem 2

```
clear
gam = 1.4;
R = .287;%kJ/(kg*K)
R = R*1000;%J/(kg*K)

cp = 1.005;%kJ/(kg*K)
cp = cp*1000;%J/(kg*K)

% state 1 givens
M1 =.2;
P1 = 100*1000;
T1 = 300;
q = 50e3;% J/(kg*K)

% state 1 solves
rho1 = P1/(R*T1);
T01 = T1*(1+M1^2*(gam-1)/2);
P01 = P1*(1+M1^2*(gam-1)/2)^(gam/(gam-1));
rho01 = rho1*(1+M1^2*(gam-1)/2)^(1/(gam-1));


% a call to compressible. input is M1, table is 3 (heat addition), input
% type is Mach #
out = compressible(M1,3,'M');
ratios.M = out(1);
ratios.P_Px = out(2);
ratios.T_Tx = out(3);
ratios.rho_rhox = out(4);
ratios.P0_P0x = out(5);
ratios.T0_T0x = out(6);
r1 = ratios;
clear out ratios

% from ratios star conditions
Px = P1/r1.P_Px;
Tx = T1/r1.T_Tx;
rhox = rho1/r1.rho_rhox;
T0x = T01/r1.T0_T0x;
P0x = P01/r1.P0_P0x;

% from heat transfer
T02 = q/cp + T01;
T02_T0x = (T02/T01)*(r1.T0_T0x);


% a call to compressible. input is T02_Tx, table is 3 (heat addition), input
% type is T0/T*
out = compressible(T02_T0x,3,'T0B');
ratios.M = out(1);
ratios.P_Px = out(2);
```

```
ratios.T_Tx = out(3);
ratios.rho_rhox = out(4);
ratios.P0_P0x = out(5);
ratios.T0_T0x = out(6);
r2 = ratios;
clear out ratios

P2 = r2.P_Px*Px;
T2 = r2.T_Tx*Tx;
rho2 = r2.rho_rhox*rhox;
P02 = r2.P0_P0x*P0x;
M2 = r2.M;

P01 = P01/1000;
P1 = P1/1000;

clc
M2
P2 = P2/1000
T2
rho2

T02
P02 = P02/1000


M2 =

    0.2178


P2 =

   99.0241


T2 =

  348.8419


rho2 =

    0.9891


T02 =

  352.1512


P02 =

  102.3512
```

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