

```

clear all
clc
%% inputs
T04=1630; % Turbine inlet temperature
B=2.93; % fan bypass ratio
m=12; % mass flow rate to core
T_inf=220 ; % ambient temperature
P_inf=0.25*101325 ; % ambient pressure
M_inf=0.85 ; % flight mach number
gamma=1.4; % ratio of specific heats
R=288.66; % gas constant
u=M_inf*sqrt(gamma*R*T_inf); % inlet velocity
Cp=gamma*R/(gamma-1) ; % specific heat
prc=linspace(3,30,50) ; % compressor pressure ratio
prf= 1.72 ; % fan pressure ratio
del_p=0; % combustor pressure loss

% isentropic efficiencies
e_diff=0.93; % inlet/diffuser
e_fan=0.85; % fan
e_n_cold=0.98; % cold stream nozzle
e_n_hot=0.90; % hot stream nozzle
e_comp=0.85; % compressor
e_turb=0.85; % turbine
e_burner=1; % burner/combustor

Q=45000000 ; % fuel heat capacity

% cold and hot stream nozzles may choke depending on altitude, B or T04
prf_critical= (1-(gamma-1)/(e_n_cold*(gamma+1)))^(gamma/(gamma-1)); % to check if cold stream nozzle chokes or not
prc_critical= (1-(gamma-1)/(e_n_hot*(gamma+1)))^(gamma/(gamma-1)) ; % to check if hot stream nozzle chokes or not

% diffuser stage
T02=T_inf*(1+(gamma-1)*0.5*M_inf^2) ;
P02=P_inf*(1+(T02/T_inf-1)*e_diff)^(gamma/(gamma-1));

% fan outlet conditons
P08 =P02*prf ; % fan outlet pressure
T08=(T02*(1+(prf^((gamma-1)/gamma)-1)/e_fan)); % fan outlet temperature

% fan nozzle exit velocity
if P_inf/P08>prf_critical % if cold stream nozzle is unchoked
    v9 =sqrt(2*e_n_cold*Cp*T08 *(1-(P_inf/P08 )^((gamma-1)/gamma))); % unchoked exit velocity at cold stream nozzle
    p9=P_inf;
else % if cold stream nozzle is choked
    p9=P08*prf_critical; % exit pressure = critical pressure
    T9=2*T08/(gamma+1); % exit temperature = critical temperature
    rho9=p9/(R*T9); % exit critical density
    v9=sqrt(gamma*R*T9); % choked exit velocity
    sprintf('Cold stream nozzle is choked, diameter-')
    2*sqrt(m*(1+B)/(rho9*v9*3.14))
end

for i=1:length(prc)
    % compressor stage
    P03(i)=(P08*prc(i));
    T03(i)=T08*(1+(prc(i)^((gamma-1)/gamma)-1)/e_comp);

    % burner fuel air ratio
    f(i)=(T04-T03(i))/(e_burner*Q/Cp-T04);

    % turbine inlet pressure
    P04(i)=P03(i)-del_p ; % given pressure loss is zero

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% compressor turbine power balance
T05(i)=T04-(T03(i)+T02-B*(T08 -T02))/(1+f(i));
P05(i)=(P04(i)*(1-(1-T05(i)/T04)/e_turb)^(gamma/(gamma-1))));
T06(i)=T05(i);
P06(i)=P05(i); %no losses in jet pipe

% specific thrust, TSFC, efficiencies

if P_inf/P06(i)>prc_critical && P_inf/P08>prf_critical % both nozzles unchoked
    v7(i)=(sqrt(2*e_n_hot*Cp*T06(i)*(1-(P_inf/P06(i))^((gamma-1)/gamma))));
    % v7 to be used if the nozzle isn't choked since it's assumed that
    % P_inf=P7 or complete expansion to atmospheric pressure
    t(i)=(1+f(i))*v7(i)+B*v9-(1+B)*u ; % unchoked nozzle

elseif prc_critical>=P_inf/P06(i) && prf_critical>=P_inf/P08 % both nozzles choked
    % choked condition, all parameters are critical conditions
    T7(i)=2*T06(i)/(gamma+1);
    p7(i)=P06(i)*prc_critical;
    v7(i)=(gamma*R*T7(i))^0.5;
    rho7(i)=p7(i)/(R*T7(i));

    t(i)=(1+f(i))*v7(i)+B*(v9-u)-u + (p7(i)-P_inf)/(rho7(i)*v7(i))+B*(p9-P_inf)/(rho9*v9); % choked nozzle thrust
    % exit velocity v7 fixed by critical pressure ratio,
    % extra pressure thrust terms come to picture
    sprintf('both nozzles choked at pressure ratio ')
    prc(i)
    sprintf('nozzle diameter')
    sqrt(m/(rho7(i)*v7(i)*3.14))

elseif P_inf/P06(i)> prc_critical && prf_critical>=P_inf/P08 % only cold nozzle chokes

    v7(i)=(sqrt(2*e_n_hot*Cp*T06(i)*(1-(P_inf/P06(i))^((gamma-1)/gamma))));
    t(i)=(1+f(i))*v7(i)+B*(v9-u)-u+B*(p9-P_inf)/(rho9*v9);
    sprintf('only cold nozzle chokes')
    prc(i)

elseif prc_critical>=P_inf/P06(i) && P_inf/P08>prf_critical % only hot nozzle chokes

    T7(i)=2*T06(i)/(gamma+1);
    p7(i)=P06(i)*prc_critical;
    v7(i)=(gamma*R*T7(i))^0.5;
    rho7(i)=p7(i)/(R*T7(i));

    t(i)=(1+f(i))*v7(i)+B*(v9-u)-u + (p7(i)-P_inf)/(rho7(i)*v7(i));
    sprintf('only hot nozzle chokes')
    prc(i)
    sprintf('nozzle diameter')
    sqrt(m/(rho7(i)*v7(i)*3.14))

end
e_prop(i)=2*t(i)*u/(t(i)*u^2+(1+f(i))*(v7(i)-u)^2+B*(v9-u)^2); % propulsive efficiency
e_therm(i)=(t(i)*u^2+(1+f(i))*(v7(i)-u)^2+B*(v9-u)^2)/(2*f(i)*Q); %thermal efficiency
end

s=f./t ; % TSFC

figure
hold on
plot(t,s)
title('TSFC against Specific thrust')
xlabel(' Specific thrust ')
ylabel('TSFC')%

figure
hold on

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plot(prc,P06)
hold on
line([0 50],[P_inf/prc_critical P_inf/prc_critical])
title('P06 vs \pi_C')
xlabel(' Compressor pressure ratio \pi_C ')
ylabel('P06')

figure
hold on
plot(prc,t/(1+B))
title('Specific thrust against \pi_c')
xlabel('Compressor pressure ratio \pi_C ')
ylabel('\tau / (dm_0/dt) N.s/kg')%

figure
hold on
plot(prc,s*1000*3600)
title('TSFC against \pi_c')
xlabel(' Compressor pressure ratio \pi_C')
ylabel('TSFC kg/kN.hr')%

figure
hold on
plot(prc,e_prop,'+' )
hold on
plot(prc,e_therm , 'o' )
plot(prc,e_prop.*e_therm, '*' )
title('T_{04}=1630 K & B=2.93')
xlabel('\pi_C Compressor pressure ratio')
ylabel('Efficiencies \eta (High to low - propulsive, thermal, overall)')%

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ans =

Cold stream nozzle is choked, diameter-

ans =

0.6225

ans =

only cold nozzle chokes

ans =

3

ans =

only cold nozzle chokes

ans =

3.5510

ans =

only cold nozzle chokes

ans =

4.1020

ans =

only cold nozzle chokes

ans =

4.6531

ans =

only cold nozzle chokes

ans =

5.2041

ans =

only cold nozzle chokes

ans =

5.7551

ans =

only cold nozzle chokes

ans =

6.3061

ans =

only cold nozzle chokes

ans =

6.8571

ans =

only cold nozzle chokes

ans =

7.4082

ans =

only cold nozzle chokes

ans =

7.9592

ans =

only cold nozzle chokes

ans =

8.5102

ans =

only cold nozzle chokes

ans =

9.0612

ans =

only cold nozzle chokes

ans =

9.6122

ans =

only cold nozzle chokes

ans =

10.1633

ans =

only cold nozzle chokes

ans =

10.7143

ans =

only cold nozzle chokes

ans =

11.2653

ans =

only cold nozzle chokes

ans =

11.8163

ans =

only cold nozzle chokes

ans =

12.3673

ans =

only cold nozzle chokes

ans =

12.9184

ans =

only cold nozzle chokes

ans =

13.4694

ans =

only cold nozzle chokes

ans =

14.0204

ans =

only cold nozzle chokes

ans =

14.5714

ans =

only cold nozzle chokes

ans =

15.1224

ans =

only cold nozzle chokes

ans =

15.6735

ans =

only cold nozzle chokes

ans =

16.2245

ans =

only cold nozzle chokes

ans =

16.7755

ans =

only cold nozzle chokes

ans =

17.3265

ans =

only cold nozzle chokes

ans =

17.8776

ans =

only cold nozzle chokes

ans =

18.4286

ans =

only cold nozzle chokes

ans =

18.9796

ans =

only cold nozzle chokes

ans =

19.5306

ans =

only cold nozzle chokes

ans =

20.0816

ans =

only cold nozzle chokes

ans =

20.6327

ans =

only cold nozzle chokes

ans =

21.1837

ans =

only cold nozzle chokes

ans =

21.7347

ans =

only cold nozzle chokes

ans =

22.2857

ans =

only cold nozzle chokes

ans =

22.8367

ans =

only cold nozzle chokes

ans =

23.3878

ans =

only cold nozzle chokes

ans =

23.9388

ans =

only cold nozzle chokes

ans =

24.4898

ans =

only cold nozzle chokes

ans =

25.0408

ans =

only cold nozzle chokes

ans =

25.5918

ans =

only cold nozzle chokes

ans =

26.1429

ans =

only cold nozzle chokes

ans =

26.6939

ans =

only cold nozzle chokes

ans =

27.2449

ans =

only cold nozzle chokes

ans =

27.7959

ans =

only cold nozzle chokes

ans =

28.3469

ans =

only cold nozzle chokes

ans =

28.8980

ans =

only cold nozzle chokes

ans =

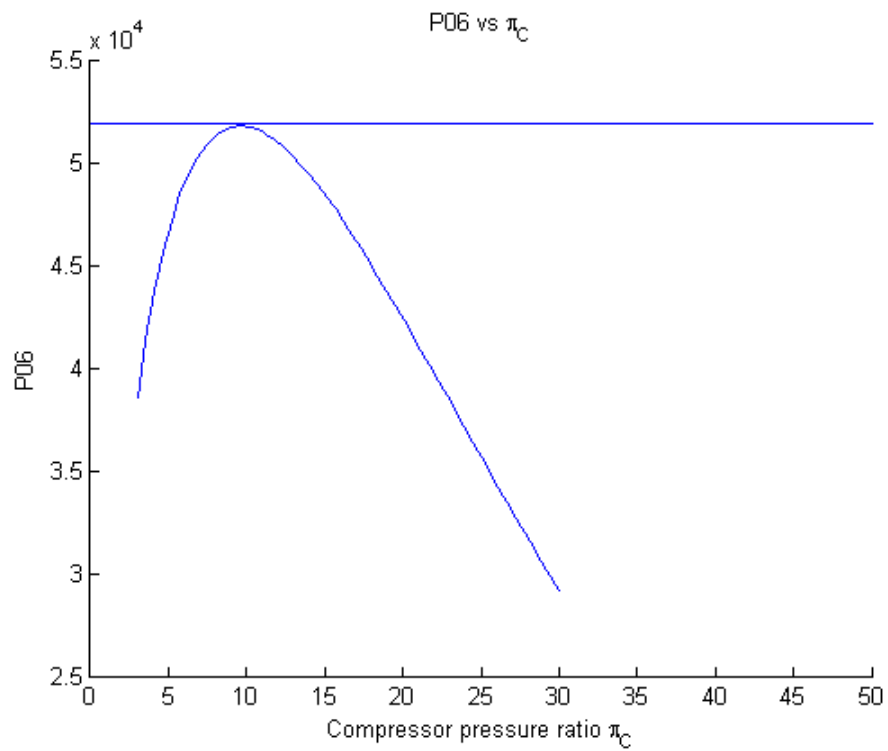
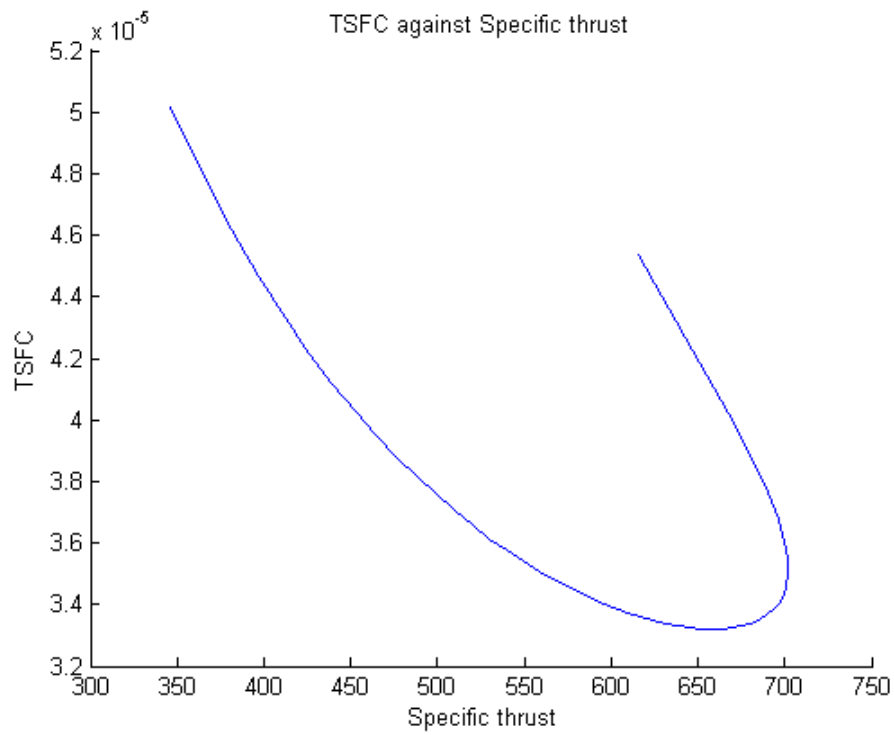
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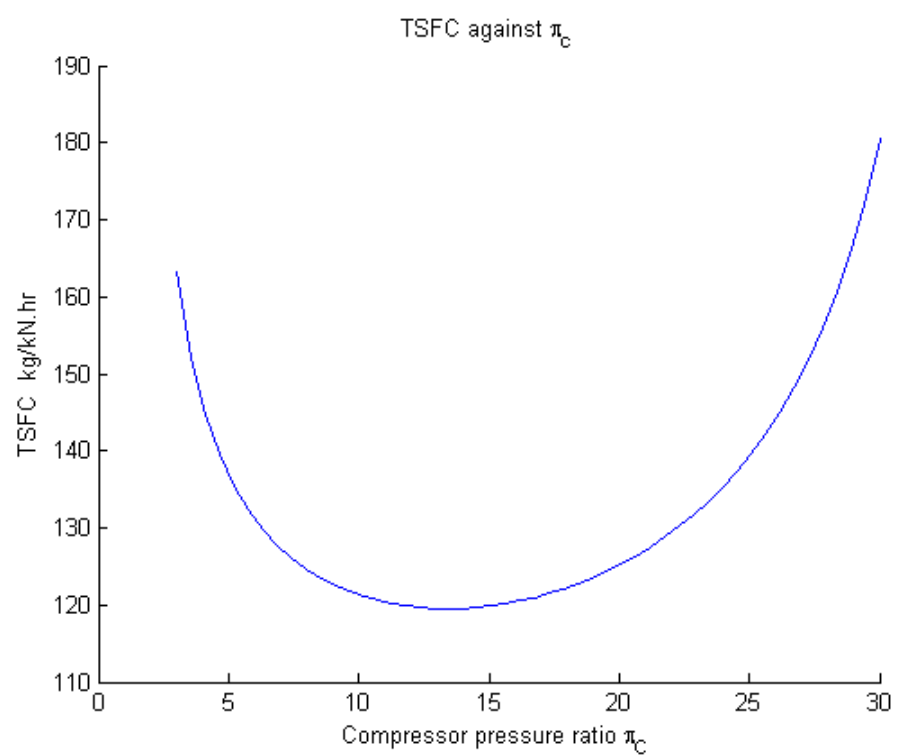
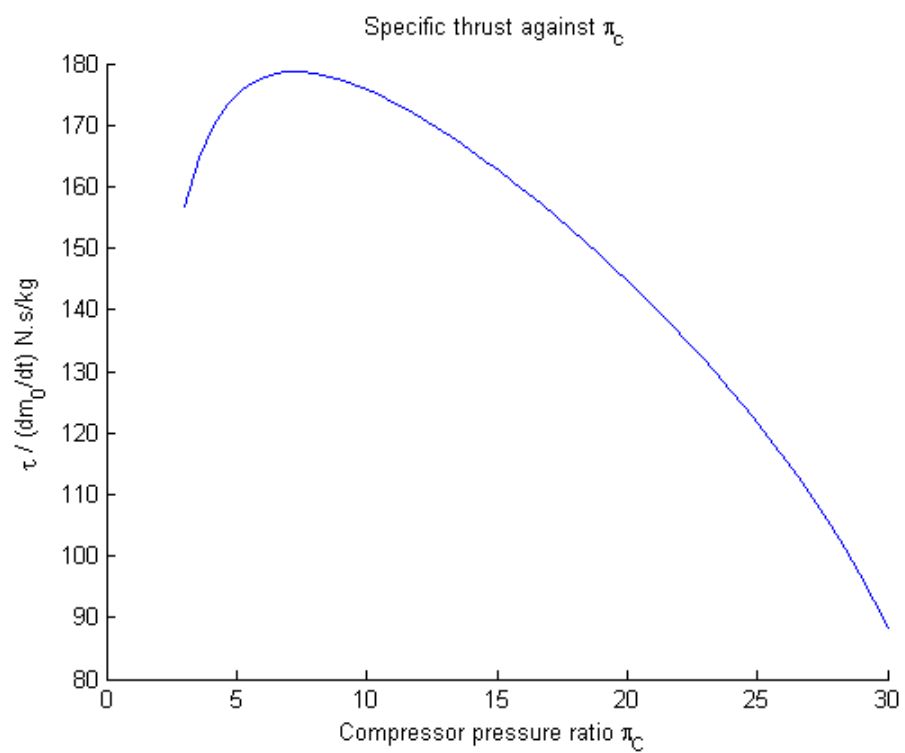
ans =

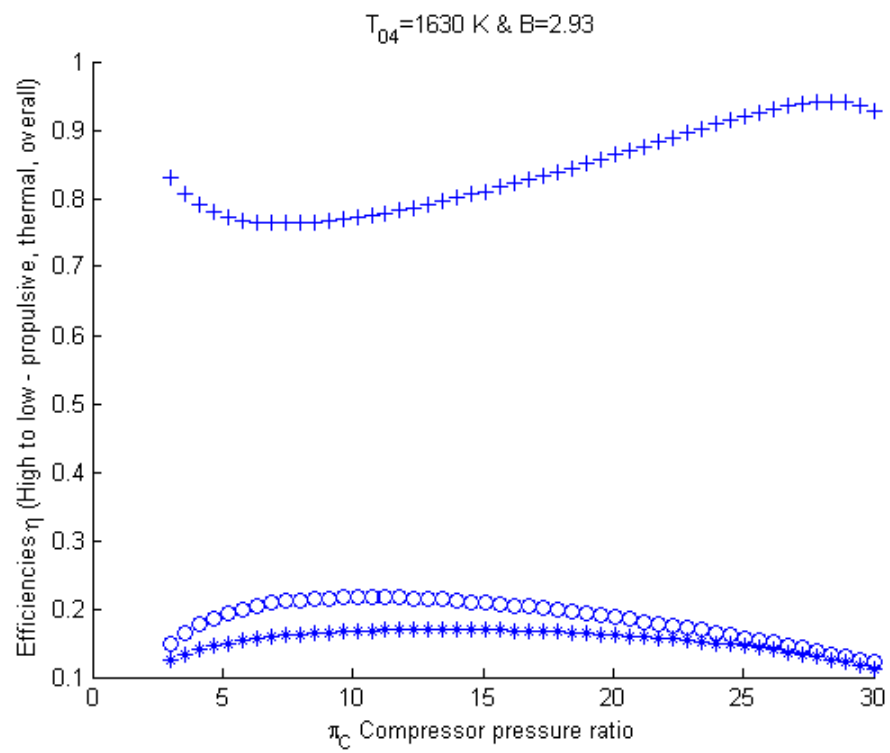
only cold nozzle chokes

ans =

30







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