```
clear all
 clc
%%%% inputs
T04=1630;                           % Turbine inlet temperature
B=5.18;                               % 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=287;                              % gas constant
u=M_inf*sqrt(gamma*R*T_inf);        % inlet velocity
Cp=gamma*R/(gamma-1) ;              % specific heat
prc=linspace(3,27,50)  ;            % 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=P02*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)=(P02*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
```

```
   % 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
```

```
    plot(prc,P06)
    hold on
    plot(prc,P_inf/prc_critical, 'o')
    title('P06 vs \pi_C')
    xlabel('  \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)
    title('TSFC against \pi_c')
    xlabel('  Compressor pressure ratio \pi_C')
    ylabel('TSFC  kg/kN.s')

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=5.17')
    xlabel('\pi_C Compressor pressure ratio')
    ylabel('\eta')
```

```
ans =

Cold stream nozzle is choked, diameter-


ans =

    1.0224


ans =

only cold nozzle chokes


ans =

     3


ans =

only cold nozzle chokes


ans =

    3.4898


ans =

only cold nozzle chokes
```

```
ans =

    3.9796


ans =

only cold nozzle chokes


ans =

    4.4694


ans =

only cold nozzle chokes


ans =

    4.9592


ans =

only cold nozzle chokes


ans =

    5.4490


ans =

only cold nozzle chokes


ans =

    5.9388


ans =

only cold nozzle chokes


ans =

    6.4286


ans =

only cold nozzle chokes


ans =

    6.9184


ans =

only cold nozzle chokes
```

```
ans =

    7.4082


ans =

only cold nozzle chokes


ans =

    7.8980


ans =

only cold nozzle chokes


ans =

    8.3878


ans =

only cold nozzle chokes


ans =

    8.8776


ans =

only cold nozzle chokes


ans =

    9.3673


ans =

only cold nozzle chokes


ans =

    9.8571


ans =

only cold nozzle chokes


ans =

   10.3469


ans =
```

```
only cold nozzle chokes


ans =

   10.8367


ans =

only cold nozzle chokes


ans =

   11.3265


ans =

both nozzles choked at pressure ratio


ans =

   11.8163


ans =

nozzle diameter


ans =

    0.2487


ans =

both nozzles choked at pressure ratio


ans =

   12.3061


ans =

nozzle diameter


ans =

    0.2480


ans =

both nozzles choked at pressure ratio


ans =

   12.7959
```

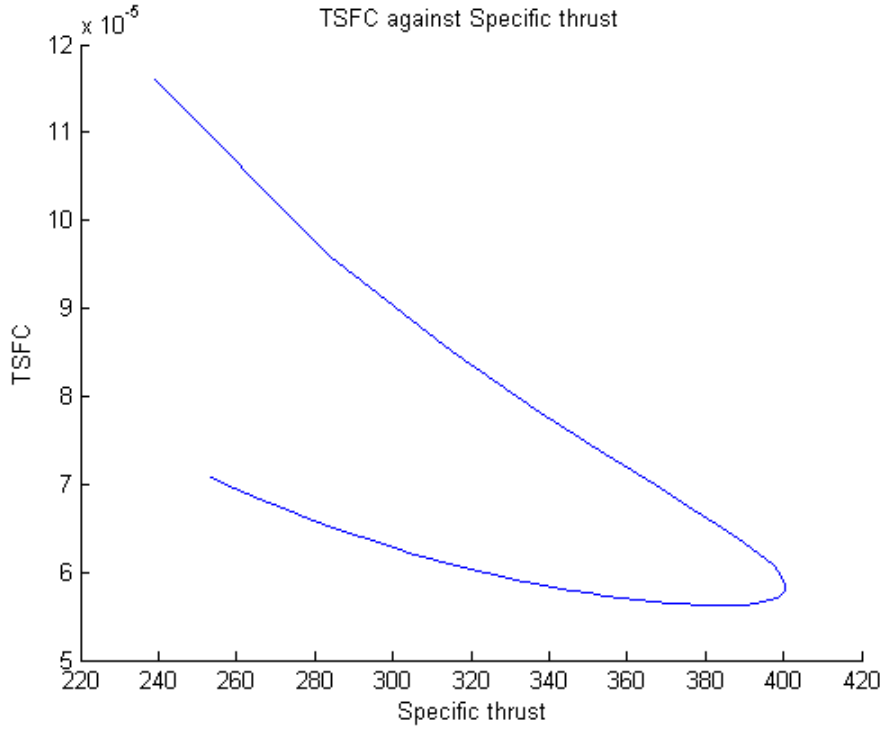
```
ans =

nozzle diameter


ans =

    0.2475


ans =

both nozzles choked at pressure ratio


ans =

   13.2857


ans =

nozzle diameter


ans =

    0.2471


ans =

only cold nozzle chokes


ans =

   13.7755


ans =

only cold nozzle chokes


ans =

   14.2653


ans =

only cold nozzle chokes


ans =

   14.7551


ans =

only cold nozzle chokes


ans =
```

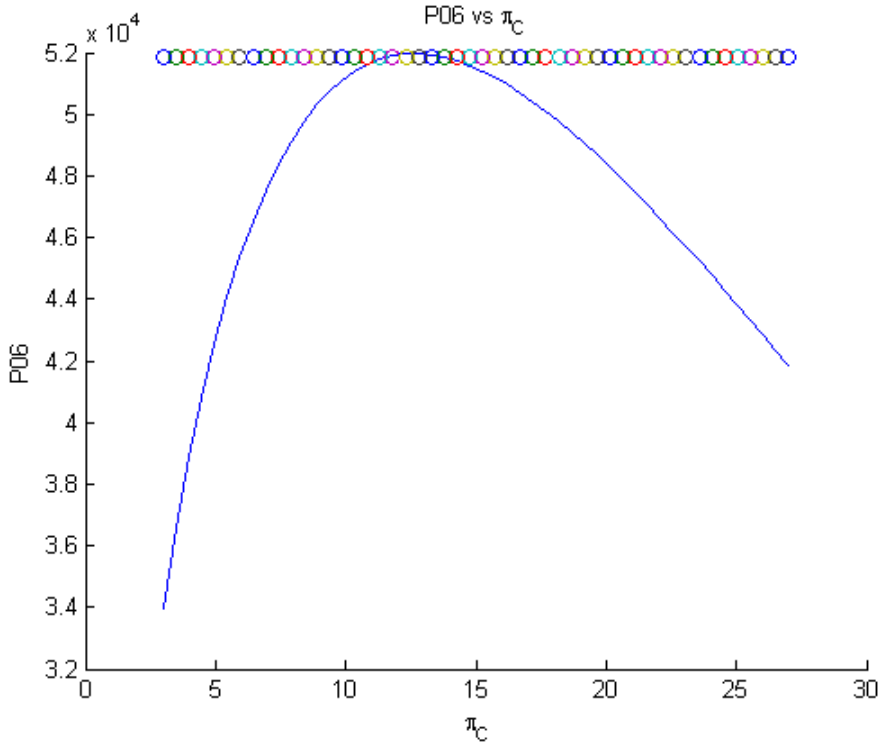
```
   15.2449

ans =

only cold nozzle chokes

ans =

   15.7347

ans =

only cold nozzle chokes

ans =

   16.2245

ans =

only cold nozzle chokes

ans =

   16.7143

ans =

only cold nozzle chokes

ans =

   17.2041

ans =

only cold nozzle chokes

ans =

   17.6939

ans =

only cold nozzle chokes

ans =

   18.1837

ans =

only cold nozzle chokes
```

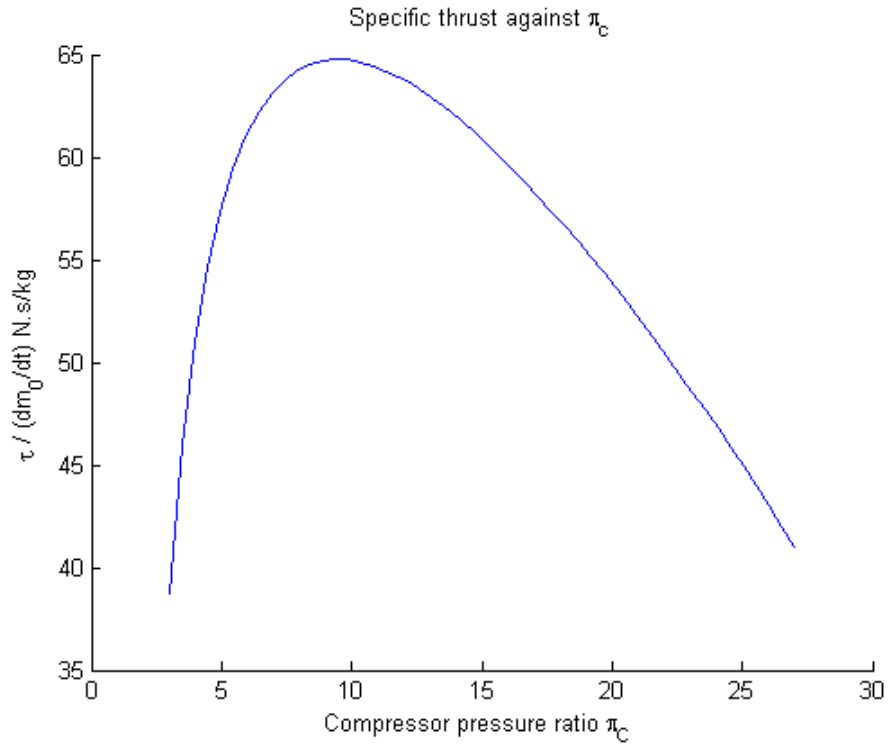
```
ans =

   18.6735


ans =

only cold nozzle chokes


ans =

   19.1633


ans =

only cold nozzle chokes


ans =

   19.6531


ans =

only cold nozzle chokes


ans =

   20.1429


ans =

only cold nozzle chokes


ans =

   20.6327


ans =

only cold nozzle chokes


ans =

   21.1224


ans =

only cold nozzle chokes


ans =

   21.6122


ans =

only cold nozzle chokes
```

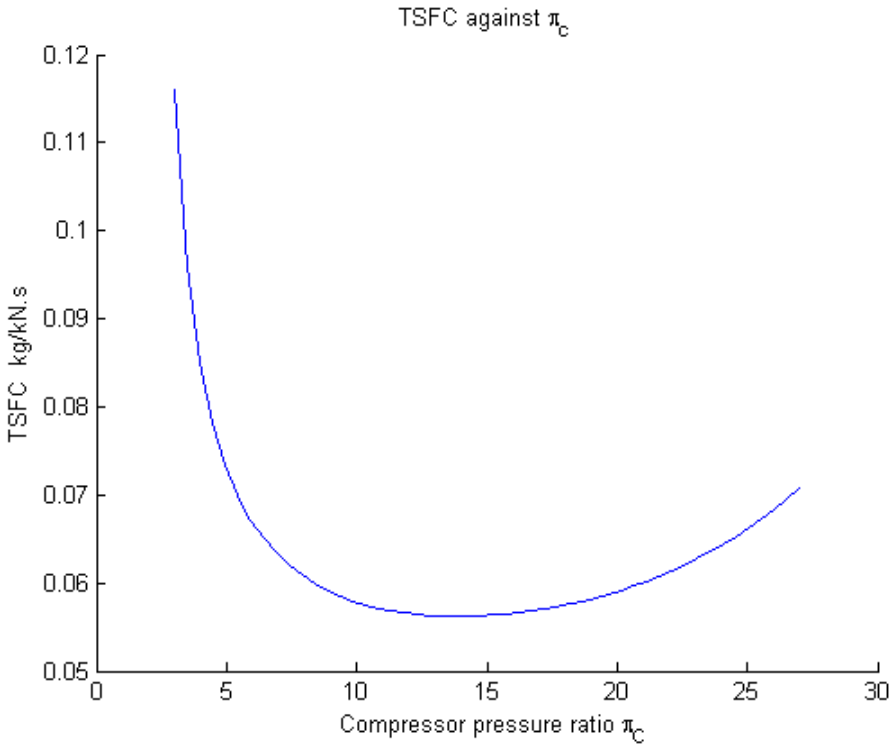
```
ans =

   22.1020


ans =

only cold nozzle chokes


ans =

   22.5918


ans =

only cold nozzle chokes


ans =

   23.0816


ans =

only cold nozzle chokes


ans =

   23.5714


ans =

only cold nozzle chokes


ans =

   24.0612


ans =

only cold nozzle chokes


ans =

   24.5510


ans =

only cold nozzle chokes


ans =

   25.0408


ans =
```

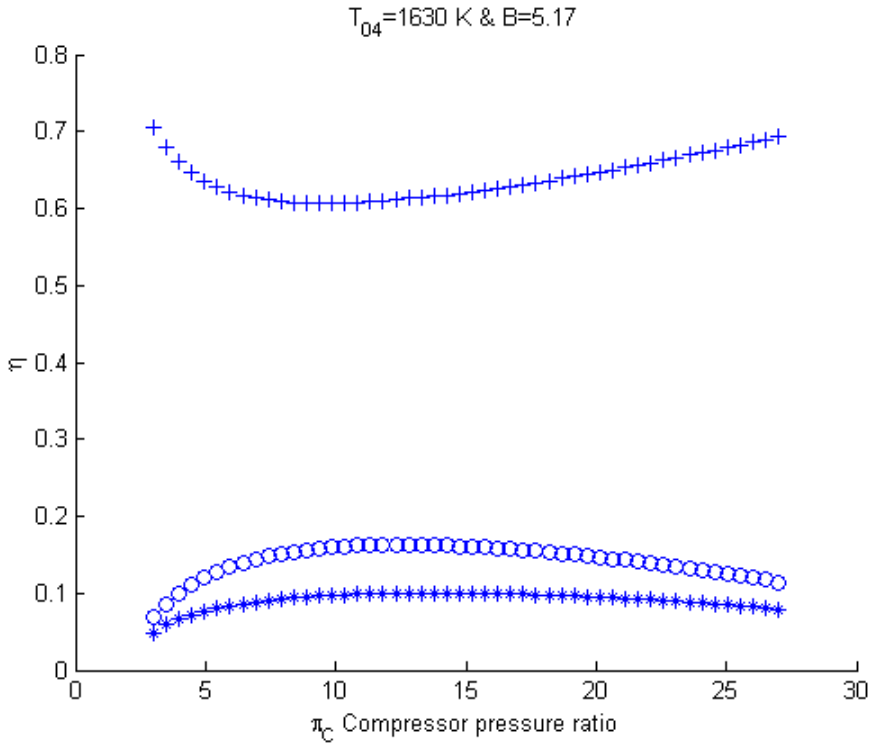
```
only cold nozzle chokes


ans =

   25.5306


ans =

only cold nozzle chokes


ans =

   26.0204


ans =

only cold nozzle chokes


ans =

   26.5102


ans =

only cold nozzle chokes


ans =

    27
```


TSFC against Specific thrust
x 10^-5
TSFC
Specific thrust
12
11
10
9
8
7
6
5
220
240
260
280
300
320
340
360
380
400
420


P06 vs π_C
x 10^4
P06
π_C
5.2
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
0
5
10
15
20
25
30


Specific thrust against π_c
τ / (dm_0/dt) N.s/kg
Compressor pressure ratio π_C
65
60
55
50
45
40
35
0
5
10
15
20
25
30


TSFC against π_c
TSFC kg/kN.s
Compressor pressure ratio π_C
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0
5
10
15
20
25
30



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