APPENDIX

PROGRAM CODE

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clc
cp=xlsread('result.xls',1,'A1:H1');
cv=xlsread('result.xls',1,'A2:H2');
qa=xlsread('result.xls',1,'A3:H3');
qr=xlsread('result.xls',1,'A4:H4');
R=0.287;
Mu=[0 10 20];
N=30;
L=0.095;
V=4*L*N;
Pu=Mu.*V^2/1000;
B=[0 0.2 0.4];
m=0.04236;
T1=300;
T0=300;
T3=2500;
rv=1:200;
rc=[1.75 2 2.25 2.5];
T2sn(1)=1;
T4sn(1)=1;
EE=1;
E=[1 0.97 0.95];
for u=1:length(B)
for i=1:length(rc)
for k=1:length(E)
for j=1:length(rv)
T2si(j)=T1*(rv(j)^0.4);
T4si(j)=T3*((rc(1)/rv(j))^0.4);
T2s(j)=T2si(j);
T4s(j)=T4si(j);
for h=1:500
Tmean12(j)=(T2s(j)-T1)/log(T2s(j)/T1);
Tmean34(j)=(T4s(j)-T3)/log(T4s(j)/T3);

Cv1(j)=cv(1)*(Tmean12(j)^2)+cv(2)*(Tmean12(j)^1.5)-
cv(3)*(Tmean12(j))+cv(4)*(Tmean12(j)^0.5)+cv(5)-
cv(6)*(Tmean12(j)^-1.5)+cv(7)*(Tmean12(j)^-2)-
cv(3)*(Tmean12(j)^-3);

Cv2(j)=cv(1)*(Tmean34(j)^2)+cv(2)*(Tmean34(j)^1.5)-
cv(3)*(Tmean34(j))+cv(4)*(Tmean34(j)^0.5)+cv(5)-
cv(6)*(Tmean34(j)^-1.5)+cv(7)*(Tmean34(j)^-2)-
cv(3)*(Tmean34(j)^-3);
T2s(j)=T1*exp((R/Cv1(j))*log(rv(j)));
T4s(j)=T3*exp(-(R/Cv2(j))*log(rv(j)/rc(1)));
end
T2(j)=((T2s(j)-T1)/E(k))+T1;
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T4(j)=T3-(E(k)*(T3-T4s(j)));
                Qa(j)=m*((qa(1)*(T3-T2(j))^3)+(qa(2)*(T3-
T2(j))^2.5)-(qa(3)*(T3-T2(j))^2)+(qa(4)*(T3-
T2(j))^1.5)+(qa(5)*(T3-T2(j)))+(qa(6)*(T3-T2(j))^-0.5)-
(qa(7)*(T3-T2(j))^-1)+(qa(8)*(T3-T2(j))^-2));
                Qr(j)=m*((qr(1)*(T4(j)-T1)^3)+(qr(2)*(T4(j)-
T1)^2.5)-(qr(3)*(T4(j)-T1)^2)+(qr(4)*(T4(j)-
T1)^1.5)+(qr(5)*(T4(j)-T1))+(qr(6)*(T4(j)-T1)^-0.5)-
(qr(7)*(T4(j)-T1)^-1)+(qr(8)*(T4(j)-T1)^-2));
P(j)=Qa(j)-Qr(j);
Ql(j)=m*B(1)*(T2(j)+T3-2*T0);
Eth(j)=P(j)/(Qa(j)+Ql(j));
Data_E(EE,j)=P(j);
Data_E(EE+1,j)=Eth(j);
end
            EE=EE+2;
end
end
end
figure(1)
hold on
plot(rv,Data_E(1,:),'b-')
plot(rv,Data_E(3,:),'g-')
plot(rv,Data_E(5,:),'r-')
xlabel('Compression ratio')
ylabel('Output power (kW)')
legend('Ec = Ee = 100%','Ec = Ee = 97%','Ec = Ee = 95%')
grid on
figure(2)
hold on
plot(rv,Data_E(2,:),'b-')
plot(rv,Data_E(4,:),'g-')
plot(rv,Data_E(6,:),'r-')
xlabel('Compression ratio')
ylabel('Thermal Efficiency')
legend('Ec = Ee = 100%','Ec = Ee = 97%','Ec = Ee = 95%')
grid on
figure(3)
hold on
plot(Data_E(2,:),Data_E(1,:),'b-')
plot(Data_E(4,:),Data_E(3,:),'g-')
plot(Data_E(6,:),Data_E(5,:),'r-')
xlabel('Thermal Efficiency')
ylabel('Output power (kW)')
legend('Ec = Ee = 100%','Ec = Ee = 97%','Ec = Ee = 95%')
grid on
QL=1;
for u=1:length(B)
for i=1:length(rc)
for k=1:length(E)
for j=1:length(rv)
T2si(j)=T1*(rv(j)^0.4);
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T4si(j)=T3*((rc(1)/rv(j))^0.4);
T2s(j)=T2si(j);
T4s(j)=T4si(j);
for h=1:500
Tmean12(j)=(T2s(j)-T1)/log(T2s(j)/T1);
Tmean34(j)=(T4s(j)-T3)/log(T4s(j)/T3);

Cv1(j)=cv(1)*(Tmean12(j)^2)+cv(2)*(Tmean12(j)^1.5)-
cv(3)*(Tmean12(j))+cv(4)*(Tmean12(j)^0.5)+cv(5)-
cv(6)*(Tmean12(j)^-1.5)+cv(7)*(Tmean12(j)^-2)-
cv(3)*(Tmean12(j)^-3);

Cv2(j)=cv(1)*(Tmean34(j)^2)+cv(2)*(Tmean34(j)^1.5)-
cv(3)*(Tmean34(j))+cv(4)*(Tmean34(j)^0.5)+cv(5)-
cv(6)*(Tmean34(j)^-1.5)+cv(7)*(Tmean34(j)^-2)-
cv(3)*(Tmean34(j)^-3);
T2s(j)=T1*exp((R/Cv1(j))*log(rv(j)));
T4s(j)=T3*exp(-(R/Cv2(j))*log(rv(j)/rc(1)));
end
T2(j)=((T2s(j)-T1)/E(1))+T1;
T4(j)=T3-(E(1)*(T3-T4s(j)));
                Qa(j)=m*((qa(1)*(T3-T2(j))^3)+(qa(2)*(T3-
T2(j))^2.5)-(qa(3)*(T3-T2(j))^2)+(qa(4)*(T3-
T2(j))^1.5)+(qa(5)*(T3-T2(j)))+(qa(6)*(T3-T2(j))^-0.5)-
(qa(7)*(T3-T2(j))^-1)+(qa(8)*(T3-T2(j))^-2));
                Qr(j)=m*((qr(1)*(T4(j)-T1)^3)+(qr(2)*(T4(j)-
T1)^2.5)-(qr(3)*(T4(j)-T1)^2)+(qr(4)*(T4(j)-
T1)^1.5)+(qr(5)*(T4(j)-T1))+(qr(6)*(T4(j)-T1)^-0.5)-
(qr(7)*(T4(j)-T1)^-1)+(qr(8)*(T4(j)-T1)^-2));
P(j)=Qa(j)-Qr(j);
Ql(j)=m*B(u)*(T2(j)+T3-2*T0);
Eth(j)=P(j)/(Qa(j)+Ql(j));
Data_ql(QL,j)=P(j);
Data_ql(QL+1,j)=Eth(j);
end
end
end
    QL=QL+2;
end
figure(4)
hold on
plot(rv,Data_ql(2,:),'b-')
plot(rv,Data_ql(4,:),'g-')
plot(rv,Data_ql(6,:),'r-')
xlabel('Compression ratio')
ylabel('Thermal Efficiency')
legend('B = 0 kJ/kg.K','B = 0.2 kJ/kg.K','B = 0.4 kJ/kg.K')
grid on
figure(5)
hold on
plot(Data_ql(2,:),Data_ql(1,:),'b-')
plot(Data_ql(4,:),Data_ql(3,:),'g-')
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plot(Data_ql(6,:),Data_ql(5,:),'r-')
xlabel('Thermal Efficiency')
ylabel('Output power (kW)')
legend('B = 0 kJ/kg.K','B = 0.2 kJ/kg.K','B = 0.4 kJ/kg.K')
grid on
PU=1;
for u=1:length(Mu)
for i=1:length(rc)
for k=1:length(E)
for j=1:length(rv)
T2si(j)=T1*(rv(j)^0.4);
T4si(j)=T3*((rc(1)/rv(j))^0.4);
T2s(j)=T2si(j);
T4s(j)=T4si(j);
for h=1:500
Tmean12(j)=(T2s(j)-T1)/log(T2s(j)/T1);
Tmean34(j)=(T4s(j)-T3)/log(T4s(j)/T3);

Cv1(j)=cv(1)*(Tmean12(j)^2)+cv(2)*(Tmean12(j)^1.5)-
cv(3)*(Tmean12(j))+cv(4)*(Tmean12(j)^0.5)+cv(5)-
cv(6)*(Tmean12(j)^-1.5)+cv(7)*(Tmean12(j)^-2)-
cv(3)*(Tmean12(j)^-3);

Cv2(j)=cv(1)*(Tmean34(j)^2)+cv(2)*(Tmean34(j)^1.5)-
cv(3)*(Tmean34(j))+cv(4)*(Tmean34(j)^0.5)+cv(5)-
cv(6)*(Tmean34(j)^-1.5)+cv(7)*(Tmean34(j)^-2)-
cv(3)*(Tmean34(j)^-3);
T2s(j)=T1*exp((R/Cv1(j))*log(rv(j)));
T4s(j)=T3*exp(-(R/Cv2(j))*log(rv(j)/rc(1)));
end
T2(j)=((T2s(j)-T1)/E(1))+T1;
T4(j)=T3-(E(1)*(T3-T4s(j)));
                Qa(j)=m*((qa(1)*(T3-T2(j))^3)+(qa(2)*(T3-
T2(j))^2.5)-(qa(3)*(T3-T2(j))^2)+(qa(4)*(T3-
T2(j))^1.5)+(qa(5)*(T3-T2(j)))+(qa(6)*(T3-T2(j))^-0.5)-
(qa(7)*(T3-T2(j))^-1)+(qa(8)*(T3-T2(j))^-2));
                Qr(j)=m*((qr(1)*(T4(j)-T1)^3)+(qr(2)*(T4(j)-
T1)^2.5)-(qr(3)*(T4(j)-T1)^2)+(qr(4)*(T4(j)-
T1)^1.5)+(qr(5)*(T4(j)-T1))+(qr(6)*(T4(j)-T1)^-0.5)-
(qr(7)*(T4(j)-T1)^-1)+(qr(8)*(T4(j)-T1)^-2));
Pu(u)=Mu(u)*V^2/1000;
P(j)=Qa(j)-Qr(j)-Pu(u);
Eth(j)=P(j)/Qa(j);
Data_pu(PU,j)=P(j);
Data_pu(PU+1,j)=Eth(j);
end
end
end
    PU=PU+2;
end
figure(6)
hold on
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```
plot(rv,Data_pu(1,:),'b-')
plot(rv,Data_pu(3,:),'g-')
plot(rv,Data_pu(5,:),'r-')
xlabel('Compression ratio')
ylabel('Output power (kW)')
legend('Mu = 0 N.s/m','Mu = 10 N.s/m','Mu = 20 N.s/m')
grid on
figure(7)
hold on
plot(rv,Data_pu(2,:),'b-')
plot(rv,Data_pu(4,:),'g-')
plot(rv,Data_pu(6,:),'r-')
xlabel('Compression ratio')
ylabel('Thermal Efficiency')
legend('Mu = 0 N.s/m','Mu = 10 N.s/m','Mu = 20 N.s/m')
grid on
figure(8)
hold on
plot(Data_pu(2,:),Data_pu(1,:),'b-')
plot(Data_pu(4,:),Data_pu(3,:),'g-')
plot(Data_pu(6,:),Data_pu(5,:),'r-')
xlabel('Thermal Efficiency')
ylabel('Output power (kW)')
legend('Mu = 0 N.s/m','Mu = 10 N.s/m','Mu = 20 N.s/m')
grid on
RC=1;
for u=1:length(Mu)
for i=1:length(rc)
for k=1:length(E)
for j=1:length(rv)
T2si(j)=T1*(rv(j)^0.4);
T4si(j)=T3*((rc(i)/rv(j))^0.4);
T2s(j)=T2si(j);
T4s(j)=T4si(j);
for h=1:500
Tmean12(j)=(T2s(j)-T1)/log(T2s(j)/T1);
Tmean34(j)=(T4s(j)-T3)/log(T4s(j)/T3);

Cv1(j)=cv(1)*(Tmean12(j)^2)+cv(2)*(Tmean12(j)^1.5)-
cv(3)*(Tmean12(j))+cv(4)*(Tmean12(j)^0.5)+cv(5)-
cv(6)*(Tmean12(j)^-1.5)+cv(7)*(Tmean12(j)^-2)-
cv(3)*(Tmean12(j)^-3);

Cv2(j)=cv(1)*(Tmean34(j)^2)+cv(2)*(Tmean34(j)^1.5)-
cv(3)*(Tmean34(j))+cv(4)*(Tmean34(j)^0.5)+cv(5)-
cv(6)*(Tmean34(j)^-1.5)+cv(7)*(Tmean34(j)^-2)-
cv(3)*(Tmean34(j)^-3);
T2s(j)=T1*exp((R/Cv1(j))*log(rv(j)));
T4s(j)=T3*exp(-(R/Cv2(j))*log(rv(j)/rc(i)));
end
T2(j)=((T2s(j)-T1)/E(1))+T1;
T4(j)=T3-(E(1)*(T3-T4s(j)));
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```
                Qa(j)=m*((qa(1)*(T3-T2(j))^3)+(qa(2)*(T3-
T2(j))^2.5)-(qa(3)*(T3-T2(j))^2)+(qa(4)*(T3-
T2(j))^1.5)+(qa(5)*(T3-T2(j)))+(qa(6)*(T3-T2(j))^-0.5)-
(qa(7)*(T3-T2(j))^-1)+(qa(8)*(T3-T2(j))^-2));
                Qr(j)=m*((qr(1)*(T4(j)-T1)^3)+(qr(2)*(T4(j)-
T1)^2.5)-(qr(3)*(T4(j)-T1)^2)+(qr(4)*(T4(j)-
T1)^1.5)+(qr(5)*(T4(j)-T1))+(qr(6)*(T4(j)-T1)^-0.5)-
(qr(7)*(T4(j)-T1)^-1)+(qr(8)*(T4(j)-T1)^-2));
Pu(1)=Mu(1)*V^2/1000;
P(j)=Qa(j)-Qr(j)-Pu(1);
Eth(j)=P(j)/Qa(j);
Data_rc(RC,j)=P(j);
Data_rc(RC+1,j)=Eth(j);
end
end
        RC=RC+2;
end
end
figure(9)
hold on
plot(rv,Data_rc(1,:),'b-')
plot(rv,Data_rc(3,:),'g-')
plot(rv,Data_rc(5,:),'r-')
plot(rv,Data_rc(7,:),'m-')
xlabel('Compression ratio')
ylabel('Output power (kW)')
legend('rc = 1.75','rc = 2.00','rc = 2.25','rc = 2.50')
grid on
figure(10)
hold on
plot(rv,Data_rc(2,:),'b-')
plot(rv,Data_rc(4,:),'g-')
plot(rv,Data_rc(6,:),'r-')
plot(rv,Data_rc(8,:),'m-')
xlabel('Compression ratio')
ylabel('Thermal Efficiency')
legend('rc = 1.75','rc = 2.00','rc = 2.25','rc = 2.50')
grid on
figure(11)
hold on
plot(Data_rc(2,:),Data_rc(1,:),'b-')
plot(Data_rc(4,:),Data_rc(3,:),'g-')
plot(Data_rc(6,:),Data_rc(5,:),'r-')
plot(Data_rc(8,:),Data_rc(7,:),'m-')
xlabel('Thermal Efficiency')
ylabel('Output power (kW)')
legend('rc = 1.75','rc = 2.00','rc = 2.25','rc = 2.50')
grid on
```