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#include <iostream.h>
#include <math.h>

/*
program:system modelling
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Description: This program simulates the performance of the thermoelectric
heat pump
             system for various operating and weather conditions in both
cooling mode and heating mode

*/
// Function prototype.
double heatpipe_resistance(double vapourT);

//This is the function that computes the heat pipe resistance.

double Rc,Rh,Th,Tc,Ta,Tin,deltT,Tm,Tv,Qh,Qc,Pe,Rsink,Rreal;
//Rc is thermal resistance of the heat sink inside the box;
//Rh is total thermal resistance of the thermal diode and the heat sink
outside the box;
//Rsink is thermal resistance of the heat sink outside the box;
//Rreal is flat heat pipe thermal resistance;
//Th is hot side temperature; Tc is cold side temperature;
//Ta is ambient temperature; Tin is room temperature;
//deltT is a temperature difference between hot and cold side;
//Tm is average temperature of hot and cold side;
//Tv is absolute temperature of vapour flow in the heat pipe;
//Qh is heat produced on hot side(heating capacity in heating mode;
// Qc is heat absorbed by TECs(cooling capacity in cooling mode);
//Pe is electric power consumption;
double a,p,k,G;
//a is Seebeck coefficient; p is resistivity;
//k is thermal conductivity; G is geometry factor;
double I,V,COP1,COP2;
//I is operating current;
//V is operating voltage;
//COP1 and COP2 are coefficient of performance;
int N,mode;
//N is the number of the thermocouples;
//mode is the working mode;

main()
{
cout<<"the working mode(cooling=1 heating=2),mode=";
cin>>mode;
if(mode==1)
{
//cooling mode calculation;
G=0.282;
N=127*8;
cout<<"the outside heat sink, Rsink=";
cin>>Rsink;
cout<<"the inside heat sink,Rc=";
cin>>Rc;
cout<<"the cooling capacity,Qc(W)=";
cin>>Qc;
```

```
cout<<"the room temperature, Tin(oC)=";
cin>>Tin;
Tin=Tin+273.15;
cout<<"the ambient temperature,Ta=";
cin>>Ta;
Ta=Ta+273.15;
Th=Ta+15;
do
{
Tc=Tin-Qc*Rc;
Tm=(Th+Tc)/2;
deltT=Th-Tc;
Tv=Th-0.1;
Rreal=heatpipe_resistance(Tv);
Qh=(Th-Ta)/(Rsink+Rreal);
Pe=Qh-Qc;
COP1=Qc/Pe;
a=22224.0e-9+930.6e-9*Tm-0.9905e-9*Tm*Tm;
p=5112.0e-8+163.4e-8*Tm+0.6279e-8*Tm*Tm;
k=62605.0e-6-277.7e-6*Tm+0.4131e-6*Tm*Tm;
I=(2*N*a*Tc-sqrt(4*N*N*a*a*Tc*Tc-4*N*p/G*(Qc+2*N*k*deltT*G)))/(2*N*p/G);
V=2*N*(I*p/G+a*deltT);
COP2=(a*I*Tc-k*deltT*G-I*I*p/(2*G))/(I*I*p/G+a*I*deltT);
cout<<"hot side temperature, Th="<<Th<<"\n";
cout<<"cold side temperature, Tc="<<Tc<<"\n";
cout<<"operating current,I="<<I<<"\n";
cout<<"power consumption,Pe="<<Pe<<"\n";
cout<<"coefficient of performance, COP1="<<COP1<<"\n";
cout<<"coefficient of performance, COP2="<<COP2<<"\n";
if((COP1-COP2)>=0.015)
{
Th=Th+0.005;
}
else
if((COP1-COP2)<=0.015)
{
Th=Th-0.005;
}

}while(sqrt((COP1-COP2)*(COP1-COP2))>0.015);


cout<<"hot side temperature, Th="<<Th<<"\n";
cout<<"cold side temperature, Tc="<<Tc<<"\n";
cout<<"operating current,I="<<I<<"\n";
cout<<"operating voltage, V="<<V<<"\n";
cout<<"power consumption,Pe="<<Pe<<"\n";
cout<<"coefficient of performance, COP1="<<COP1<<"\n";
cout<<"coefficient of performance, COP2="<<COP2<<"\n";
}

else
{
//heating mode calculation;
G=0.282;
N=127*8;
cout<<"the outside heat sink, Rsink=";
cin>>Rsink;
```

```
cout<<"the inside heat sink,Rc=";
cin>>Rc;
cout<<"the heating capacity,Qh(W)=";
cin>>Qh;
cout<<"the room temperature, Tin(oC)=";
cin>>Tin;
Tin=Tin+273.15;
cout<<"the ambient temperature,Ta=";
cin>>Ta;
Ta=Ta+273.15;
Tc=Ta-1;
do
{
Th=Tin+Qh*Rc;
Tm=(Th+Tc)/2;
deltT=Th-Tc;
Tv=Tc+0.1;
Rreal=heatpipe_resistance(Tv);
Qc=(Ta-Tc)/(Rsink+Rreal);
Pe=Qh-Qc;
COP1=1+Qc/Pe;
a=22224.0e-9+930.6e-9*Tm-0.9905e-9*Tm*Tm;
p=5112.0e-8+163.4e-8*Tm+0.6279e-8*Tm*Tm;
k=62605.0e-6-277.7e-6*Tm+0.4131e-6*Tm*Tm;
I=(2*N*a*Tc-sqrt(4*N*N*a*a*Tc*Tc-4*N*p/G*(Qc+2*N*k*deltT*G)))/(2*N*p/G);
V=2*N*(I*p/G+a*deltT);
COP2=1+(a*I*Tc-k*deltT*G-I*I*p/(2*G))/(I*I*p/G+a*I*deltT);
cout<<"hot side temperature, Th="<<Th<<"\n";
cout<<"cold side temperature, Tc="<<Tc<<"\n";
cout<<"operating current,I="<<I<<"\n";
cout<<"operating voltage, V="<<V<<"\n";
cout<<"power consumption,Pe="<<Pe<<"\n";
cout<<"coefficient of performance, COP1="<<COP1<<"\n";
cout<<"coefficient of performance, COP2="<<COP2<<"\n";
if((COP1-COP2)>=0.015)
{
Tc=Tc+0.005;
}
else
if((COP1-COP2)<=0.015)
{
Tc=Tc-0.005;
}

}while(sqrt((COP1-COP2)*(COP1-COP2))>0.015);


cout<<"hot side temperature, Th="<<Th<<"\n";
cout<<"cold side temperature, Tc="<<Tc<<"\n";
cout<<"operating current,I="<<I<<"\n";
cout<<"operating voltage, V="<<V<<"\n";
cout<<"power consumption,Pe="<<Pe<<"\n";
cout<<"coefficient of performance, COP1="<<COP1<<"\n";
cout<<"coefficient of performance, COP2="<<COP2<<"\n";
}
return 0;
}
```

```
double heatpipe_resistance(double vapourT)
{
double ro,ri,le,kp,Fv,la,lc,J,roc,ric,rv,rvc,ke,t,hfg,rov,pi,Awall;
//Calculation of thermal resistance of heat pipe of the test rig


//ro is radius of the evaporation section of the heat pipe (outer
surface);
//ri is radius of the evaporation section of the heat pipe (inner
surface);
//le is length of the evaporation section of the heat pipe;
//kp is thermal conductivity of the heat pipe wall;
//fv is frictional resistance coefficient of the vapour flow in the heat
pipe;
//la is length of the adiabatic section of the pipe;
//lc is length of the condensation section of the heat pipe;
//roc is radius of the condensation section of the heat pipe(outer
surface);
//ric is radius of the condensation section of the heat pipe (inner
surface);
//rv is radius of the vapour column in the evaporation section (99% of
the inner surface radius);
//rvc is radius of the vapour column in the condensation section of the
heat pipe;
//ke is thermal conductivity of the liquid film (or wicked)space;
//hfg is latent heat of n-petane;
//rov is density of vapour flow;
//pi is 3.1415926;
//Awall is the area of the flat heat pipe;
//Rreal is the heat resistance of the flat heat pipe;

double Rpe,RRv,Rpc,Rwe,Rwc,Rhp;
//RRv is heat resistance of the vapour flow in the heat pipes;
//Rpe is the heat resistance of the evaporator wall;
//Rpc is the heat resistance of the condenser wall;
//Rwe is the heat resistance of the liquid film in the evaporator;
//Rwc is the heat resistance of the liquid film in the condenser;
//Rhp is the overall heat resistance of the heat pipes;


ro=(0.003+(0.005+0.003))/2+0.005;
ri=0.005;
le=0.32;
kp=397;
ke=0.131;
Fv=0.014;
la=0.015;
lc=0.32;
J=1;
roc=(0.003+(0.005+0.003))/2+0.005;
ric=0.005;
rv=0.005-0.005*0.01;
rvc=0.005-0.005*0.01;
pi=3.1415926;
Awall=0.32*0.15;

t=Tv-273.15;
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```
if((t>=-20)&&(t<=-10))
{
hfg=1000*(398.5+(390.7-398.5)*(t+20)/10);
rov=0.313+(0.511-0.313)*(t+20)/10;
}
else
if((t>-10)&&(t<=0))
{
hfg=1000*(390.7+(380.7-390.7)*(t+10)/10);
rov=0.511+(0.798-0.511)*(t+10)/10;
}
else
if((t>0)&&(t<=10))
{
hfg=1000*(380.7+(374.7-380.7)*t/10);
rov=0.798+(1.198-0.798)*t/10;
}
else
if((t>10)&&(t<=20))
{
hfg=1000*(374.7+(368.5-374.5)*(t-10)/10);
rov=1.198+(1.741-1.198)*(t-10)/10;
}
else
if((t>20)&&(t<=30))
{
hfg=1000*(368.5-0.82*(t-20));
rov=1.74+(2.45789-1.741)*(t-20)/10;
}
else
if((t>30)&&(t<=40))
{
hfg=1000*(360.3+(352-360.3)*(t-30)/10);
rov=2.45789+(2.89318-2.45789)*(t-30)/10;
}
else
if((t>40)&&(t<=50))
{
hfg=1000*(352+(343.7-352)*(t-40)/10);
rov=2.45789+(2.89318-2.45789)*(t-30)/10;
}
else
if((t>50)&&(t<=60))
{
hfg=1000*(343.7+(335.1-343.7)*(t-50)/10);
rov=4.56589+(6.04367-4.56589)*(t-50)/10;
}
else
if((t>60)&&(t<=70))
{
hfg=1000*(335.1+(326.3-335.1)*(t-60)/10);
rov=6.04367+(7.8725-6.04367)*(t-60)/10;
}
else
if((t>70)&&(t<=80))
{
hfg=1000*(326.3+(317.1-326.3)*(t-70)/10);
rov=7.8725+(10.1143-7.8725)*(t-70)/10;
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}
else
if((t>80)&&(t<=90))
{
hfg=1000*(317.1+(307.3-317.1)*(t-80)/10);
rov=10.1143+(12.8425-10.1143)*(t-80)/10;
}
cout<<"hfg, hfg="<<hfg<<"\n";
cout<<"rov, rov="<<rov<<"\n";

Rpe = ro*ro*log(ro/ri)/(2*le*kp);
Rwe = ro*ro*log(ri/rv)/(2*le*ke);
RRv = pi * ro*ro*Fv* (273+t)*(le/6+la+lc/6)/(rov*hfg*J);
Rwc = ro*ro * log(ric/rvc)/(2*lc*ke);
Rpc = ro*ro* log(roc/ric)/(2*lc*kp);

Rhp=Rpe+Rwe+RRv+Rwc+Rpc;

Rreal=Awall*Rhp/(11*pi*ro*ro);

cout<<"ro, ro="<<ro<<"\n";
cout<<"ri, ri="<<ri<<"\n";
cout<<"Heat resistance of evaporator wall, Rpe="<<Rpe<<"\n";
cout<<"Heat resistance of evaporator film, Rwe="<<Rwe<<"\n";
cout<<"Heat resistance of vapour flow,RRv="<<RRv<<"\n";
cout<<"Heat resistance of condenser film,Rwc="<<Rwc<<"\n";
cout<<"Heat resistane of condenser wall, Rpc="<<Rpc<<"\n";
cout<<"Overall heat resistance of the heat pipes, Rhp="<<Rhp<<"\n";
cout<<"Overall heat resistance of the flat heat pipe,
Rreal="<<Rreal<<"\n";
return (Rreal);
}
```