ภาคผนวก

ภาคผนวก ก

การหา $\bar{R}_b$ ในกรณีที่ระนาบเอียงมี $\gamma \neq 0^\circ$ และ $\gamma \neq 180^\circ$

การหา $\overline{R}_b$ ในกรณีที่ระนาบเอียงมี $\gamma \neq 0^{\circ}$ และ $\gamma \neq 180^{\circ}$

$$\overline{R}_b = \frac{\begin{array}{l}(\cos\theta\sin\delta\sin\varsigma)(\varphi_{SS}-\varphi_{Sr})(\pi/180)\\ -(\sin\delta\cos\varsigma\sin\theta\cos\gamma)(\varphi_{SS}-\varphi_{Sr})(\pi/180)\\ +(\cos\varsigma\cos\delta\cos\theta)(\sin\varphi_{SS}-\sin\varphi_{Sr})\\ +(\cos\delta\cos\gamma\sin\varsigma\sin\theta)(\sin\varphi_{SS}-\sin\varphi_{Sr})\\ -(\cos\delta\sin\theta\sin\gamma)(\cos\varphi_{SS}-\cos\varphi_{Sr})\end{array}}{2(\cos\varsigma\cos\delta\sin\varphi_S+(\pi/180)\varphi_S\sin\varsigma\sin\delta)} \qquad (ก.1)$$

เมื่อ φ_{Sr} และ φ_{SS} คือ มุมชั่วโมงพระอาทิตย์ขึ้นและพระอาทิตย์ตกของระนาบเอียง ซึ่งสามารถหาจาก

กรณี $\gamma > 0^{\circ}$

$$\omega_{Sr} = -\min\left\{\varphi_S, \cos^{-1}\left[\frac{(AB+\sqrt{A^2-B^2+1})}{A^2+1}\right]\right\} \qquad (ก.2)$$

$$\omega_{SS} = \min\left\{\varphi_S, \cos^{-1}\left[\frac{(AB-\sqrt{A^2-B^2+1})}{A^2+1}\right]\right\} \qquad (ก.3)$$

กรณี $\gamma < 0^{\circ}$

$$\omega_{Sr} = -\min\left\{\varphi_S, \cos^{-1}\left[\frac{(AB-\sqrt{A^2-B^2+1})}{A^2+1}\right]\right\} \qquad (ก.4)$$

$$\omega_{SS} = \min\left\{\varphi_S, \cos^{-1}\left[\frac{(AB+\sqrt{A^2-B^2+1})}{A^2+1}\right]\right\} \qquad (ก.5)$$

เมื่อ $A = \dfrac{\cos\varsigma}{(\sin\gamma\tan\theta)} + \dfrac{\sin\varsigma}{\tan\gamma}$, $B = \tan\delta\left\{\dfrac{\cos\varsigma}{\tan\gamma} - \dfrac{\sin\varsigma}{(\sin\gamma\tan\theta)}\right\}$

ภาคผนวก ข

สมการคำนวณคุณสมบัติอากาศ

สมการคำนวณคุณสมบัติอากาศ (ได้จากการ Interporation ตารางคุณสมบัติอากาศในช่วงอุณหภูมิ 275-325 K ของ Incropera, 1985)

$$\rho = -0.003997 \times T_{air} + 2.377225 \quad (ข.1)$$

$$C_p = 0.03 \times T_{air} + 998.25 \quad (ข.2)$$

$$\nu = (0.0948 \times T_{air} - 12.405) \times 10^{-6}) \quad (ข.3)$$

$$k = (0.077 \times T_{air} + 3.125) \times 10^{-3} \quad (ข.4)$$

$$\mathrm{Pr} = -0.0002 \times T_{air} + 0.7685 \quad (ข.5)$$

เมื่อ T_{air} คือ อุณหภูมิอากาศ

ภาคผนวก ค

โปรแกรมแบบจำลองสภาพทางคณิตศาสตร์

```
clear

%*************************** CAL. Tin Swine house ****************************

Tenter    = input('Tenter ');
Tleave    = input('Tleave ');
Ts        = input('Ts');
Tm        = (Tenter+Tleave)./2;
V_rate    = input('volume flow rate Q, m^3/s ');
N         = input('number of duct ');
Acd       = input('cross section area of 1 duct ');
D         = input('diameter of duct ');
airdensity = -3.997e-003*Tenter+2.3605;
Cp        = 1000;
m_rate    = V_rate*airdensity;
m_rate_d = m_rate/N;
Um        = m_rate_d./(airdensity.*Acd);
Apt       = input('total surface area ');
Ac        = input('total space cross sectional area ');
Tfi       = (Tenter+Tleave)./2;
k_Tfi     = (7.7e-002*Tfi+3.2e+000)*0.001;
kineviscos_Tfi = (9.48e-002*Tfi-1.255e+001)*0.000001;
airdensity      = -3.997e-003*Tfi+2.3605;
airdensityI     = -3.997e-003*Tenter+2.3605;
V               = Um;
Re              = Um*D./kineviscos_Tfi;
if Re<2500
  h_id          = 2.47*k_Tfi/D;
else disp('Re not in the Range ')
end
DeltaTm         = (Tenter-Tleave)./(log((Tenter-Ts)./(Tleave-Ts)));
Tleave1         = Tenter-(h_id.*Apt.*DeltaTm)./(airdensityI.*V.*Ac.*Cp);
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```
if abs(Tleave1-Tleave) >= 0.001
  while abs(Tleave1-Tleave)/Tleave >= 0.1
   Tfi             = (Tenter+Tleave1)./2;
   k_Tfi           = (7.7e-002*Tfi+3.2e+000)*0.001;
   kineviscos_Tfi = (9.48e-002*Tfi-1.255e+001)*0.000001;
   airdensity      = -3.997e-003*Tfi+2.3605;
     Re            = Um*D./kineviscos_Tfi;
       if Re<2300
     h_id           = 2.47*k_Tfi./D;
           else disp('Re not in the Range ')
       end
  DeltaTm          = (Tenter-Tleave1)./(log((Tenter-Ts)./(Tleave1-Ts)));
  TT               = Tenter-(h_id.*Apt.*DeltaTm)./(airdensity.*V.*Ac.*Cp);
  ii               = Tleave1;
  Tleave           = ii;
  Tleave1          = TT;
  end
end
Tinlet              = Tleave1;
beta_r1             = input('angle of roof ')*pi/180;
beta_r2             = -26.56*pi/180;
gamma_r1            = input('surface azimuth angel of roof 1 ')*pi/180;
gamma_r2            = input('surface azimuth angel of roof 2 ')*pi/180;
A_r1                = input('Area of roof1 ');
A_r2                = input('Area of roof2 ');
absorp_r            = input('absorptivity ');
Emissivity_r        = input('Emissivity of roof ');
k_r                 = input('conduct of roof ');
L_r                 = input('Length of roof ');
thick_r             = input('thick of roof ');
beta_w              = input('Tile of wall ')*pi/180;
gamma_w1            = input('surface azimuth angel of wall 1 ')*pi/180;
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```
gamma_w2        = input('surface azimuth angel of wall 2 ')*pi/180;
A_w1            = input('Wall 1 Area ');
A_w2            = input('Wall 2 Area ');
absorp_w        = input('absorptivity of wall ');
Emissivity_w    = input('Emissivity of wall ');
k_w             = input('conduct of wall  ');
L_w             = input('Length of wall ');
thick_w         = input('thick of wall ');
j               = input('start hour angle ');
k               = input('number of point to plot every 5 minute ');
time            = input('range of time to find temp.');
n               = input('day of year ');
H               = input('Mounthly average daily solar radiation MJ/m^2.day ');
Gsc             = 1353;
low             = input('Refleatance of ground ');
W               = input('hour angel ')*pi/180;
fee             = (18+47/60)*pi/180;
delta           = (23.45*sin(360*(284+n)/365*pi/180))*pi/180;
Ws              = acos(-tan(fee)*tan(delta));
Ho              = 24*3600/pi*Gsc*((1+0.033*cos(360*n/365*pi/180))*(cos(fee)*cos(delta)*sin(Ws)+Ws*sin
(fee)*sin(delta)));
Kt              = H/Ho;
Hd              = Ho*(-4.6408+26.5495*Kt-28.3422*Kt^2-31.4546*Kt^3+46.4421*Kt^4);
aa              = 0.514+0.228*sin((Ws*180/pi-60)*pi/180);
bb              = 0.512+0.083*sin((Ws*180/pi-60)*pi/180);
rt              = pi/24*(aa+bb*cos(W))*(cos(W)-cos(Ws))/(sin(Ws)-Ws*cos(Ws));
I               = H*rt;
rd              = pi/24*(cos(W)-cos(Ws))/(sin(Ws)-Ws*cos(Ws));
Id              = Hd*rd;
Ib              = I-Id;
if gamma_r1>0
  gamma         = gamma_r1;
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```
 beta          = beta_r1;
 A             = cos(fee)/(sin(gamma)*tan(beta))+sin(fee)/tan(gamma);
 B             = tan(delta)*(cos(fee)/tan(gamma)-sin(fee)/(sin(gamma)*tan(beta)));
 Wsr1          = Ws;
 Wsr2          = acos((A*B+(A^2-B^2+1)^(1/2))/(A^2+1));

if Wsr1<Wsr2
   Wsr  = -Wsr1;
 elseif Wsr2<Wsr1
   Wsr  = -Wsr2;
 end
 Wss1    = Ws;
 Wss2    = acos((A*B-(A^2-B^2+1)^(1/2))/(A^2+1));
 if Wss1<Wss2
   Wss  = Wss1;
 elseif Wss2<Wss1
   Wss  = Wss2;
 end
 Rb_r1   = ((cos(beta)*sin(delta)*sin(fee)*(Wss-Wsr))-(sin(delta)*cos(fee)*sin(beta)*cos(gamma)*(Wss-Wsr))+
(cos(fee)*cos(delta)*cos(beta)*(sin(Wss)-sin(Wsr)))+(cos(delta)*cos(gamma)*sin(fee)*sin(beta)*(sin(Wss)-sin
(Wsr)))-(cos(delta)*sin(beta)*sin(gamma)*(cos(Wss)-cos(Wsr))))/(2*(cos(fee)*cos(delta)*sin(Ws)+Ws*sin
(fee)*sin(delta)));

elseif gamma_r1<0
 gamma = gamma_r1;
 beta    = beta_r1;
 A       = cos(fee)/(sin(gamma)*tan(beta))+sin(fee)/tan(gamma);
 B       = tan(delta)*(cos(fee)/tan(gamma)-sin(fee)/(sin(gamma)*tan(beta)));
 Wsr1   = Ws;
 Wsr2   = acos((A*B-(A^2-B^2+1)^(1/2))/(A^2+1));
 if Wsr1<Wsr2
   Wsr  = -Wsr1;
```

```
  elseif Wsr2<Wsr1
    Wsr  = -Wsr2;
  end
  Wss1    = Ws;
  Wss2    = acos((A*B+(A^2-B^2+1)^(1/2))/(A^2+1));
  if Wss1<Wss2
    Wss   = Wss1;
  elseif Wss2<Wss1
    Wss  = Wss2;
  end
  Rb_r1   = ((cos(beta)*sin(delta)*sin(fee)*(Wss-Wsr))-(sin(delta)*cos(fee)*sin(beta)*cos(gamma)*(Wss-Wsr))+
(cos(fee)*cos(delta)*cos(beta)*(sin(Wss)-sin(Wsr)))+(cos(delta)*cos(gamma)*sin(fee)*sin(beta)*(sin(Wss)-sin
(Wsr)))-(cos(delta)*sin(beta)*sin(gamma)*(cos(Wss)-cos(Wsr))))/(2*(cos(fee)*cos(delta)*sin(Ws)+Ws*sin
(fee)*sin(delta)));
elseif gamma_r1==0
  gamma  = gamma_r1;
  beta      = beta_r1;
  Wsp1    = acos(-tan(fee)*tan(delta));
  Wsp2    = acos(-tan(fee-beta)*tan(delta));
  if Wsp1<Wsp2
    Wsp   = Wsp1;
  elseif Wsp2<Wsp1
    Wsp   = Wsp2;
  end
  Rb_r1   = (cos(fee-beta)*cos(delta)*sin(Wsp)+Wsp*sin(fee-beta)*sin(delta))/(cos(fee)*cos(delta)*sin
(Ws)+Ws*sin(fee)*sin(delta));
end
Ht_r1     = H*(1-Hd/H)*Rb_r1+Hd*(1+cos(beta_r1))/2+low*H*(1-cos(beta_r1))/2;
It_r1     = rt*Ht_r1;
Qabsorp_r1  = absorp_r*It_r1/3600;
if gamma_r2>0
  gamma= gamma_r2;
```

```
  beta     = beta_r2;
  A        = cos(fee)/(sin(gamma)*tan(beta))+sin(fee)/tan(gamma);
  B        = tan(delta)*(cos(fee)/tan(gamma)-sin(fee)/(sin(gamma)*tan(beta)));
  Wsr1     = Ws;
  Wsr2     = acos((A*B+(A^2-B^2+1)^(1/2))/(A^2+1));
  if Wsr1<Wsr2
    Wsr = -Wsr1;
  elseif Wsr2<Wsr1
    Wsr  = -Wsr2;
  end
  Wss1     = Ws;
  Wss2     = acos((A*B-(A^2-B^2+1)^(1/2))/(A^2+1));
  if Wss1<Wss2
    Wss  = Wss1;
  elseif Wss2<Wss1
    Wss  = Wss2;
  end
  Rb_r2   = ((cos(beta)*sin(delta)*sin(fee)*(Wss-Wsr))-(sin(delta)*cos(fee)*sin(beta)*cos(gamma)*(Wss-Wsr))+
(cos(fee)*cos(delta)*cos(beta)*(sin(Wss)-sin(Wsr)))+(cos(delta)*cos(gamma)*sin(fee)*sin(beta)*(sin(Wss)-sin
(Wsr)))-(cos(delta)*sin(beta)*sin(gamma)*(cos(Wss)-cos(Wsr))))/(2*(cos(fee)*cos(delta)*sin(Ws)+Ws*sin
(fee)*sin(delta)));
elseif gamma_r2<0
  gamma = gamma_r2;
  beta     = beta_r2;
  A        = cos(fee)/(sin(gamma)*tan(beta))+sin(fee)/tan(gamma);
  B        = tan(delta)*(cos(fee)/tan(gamma)-sin(fee)/(sin(gamma)*tan(beta)));
  Wsr1     = Ws;
  Wsr2     = acos((A*B-(A^2-B^2+1)^(1/2))/(A^2+1));
  if Wsr1<Wsr2
    Wsr  = -Wsr1;
  elseif Wsr2<Wsr1
    Wsr  = -Wsr2;
```

```
  end
  Wss1    = Ws;
  Wss2    = acos((A*B+(A^2-B^2+1)^(1/2))/(A^2+1));
  if Wss1<Wss2
    Wss  = Wss1;
  elseif Wss2<Wss1
    Wss  = Wss2;
  end
  Rb_r2   = ((cos(beta)*sin(delta)*sin(fee)*(Wss-Wsr))-(sin(delta)*cos(fee)*sin(beta)*cos(gamma)*(Wss-Wsr))+
(cos(fee)*cos(delta)*cos(beta)*(sin(Wss)-sin(Wsr)))+(cos(delta)*cos(gamma)*sin(fee)*sin(beta)*(sin(Wss)-sin
(Wsr)))-(cos(delta)*sin(beta)*sin(gamma)*(cos(Wss)-cos(Wsr))))/(2*(cos(fee)*cos(delta)*sin(Ws)+Ws*sin
(fee)*sin(delta)));
elseif gamma_r2==0
  gamma   = gamma_r2;
  beta    = beta_r2;
  Wsp1    = acos(-tan(fee)*tan(delta));
  Wsp2    = acos(-tan(fee-beta)*tan(delta));
  if Wsp1<Wsp2
    Wsp  = Wsp1;
  elseif Wsp2<Wsp1
    Wsp  = Wsp2;
  end
  Rb_r2   = (cos(fee-beta)*cos(delta)*sin(Wsp)+Wsp*sin(fee-beta)*sin(delta))/(cos(fee)*cos(delta)*sin
(Ws)+Ws*sin(fee)*sin(delta));
end
Ht_r2     = H*(1-Hd/H)*Rb_r2+Hd*(1+cos(beta_r2))/2+low*H*(1-cos(beta_r2))/2;
It_r2     = rt*Ht_r2;
Qabsorp_r2  = absorp_r*It_r2/3600;
if gamma_w1>0
  gamma= gamma_w1;
  beta    = beta_w;
  A       = cos(fee)/(sin(gamma)*tan(beta))+sin(fee)/tan(gamma);
```

```
 B      = tan(delta)*(cos(fee)/tan(gamma)-sin(fee)/(sin(gamma)*tan(beta)));
 Wsr1   = Ws;
 Wsr2   = acos((A*B+(A^2-B^2+1)^(1/2))/(A^2+1));
 if Wsr1<Wsr2
   Wsr  = -Wsr1;
 elseif Wsr2<Wsr1
   Wsr  = -Wsr2;
 end
 Wss1    = Ws;
 Wss2    = acos((A*B-(A^2-B^2+1)^(1/2))/(A^2+1));
 if Wss1<Wss2
   Wss  = Wss1;
 elseif Wss2<Wss1
   Wss  = Wss2;
 end
 Rb_w1   = ((cos(beta)*sin(delta)*sin(fee)*(Wss-Wsr))-(sin(delta)*cos(fee)*sin(beta)*cos(gamma)*(Wss-Wsr))+
(cos(fee)*cos(delta)*cos(beta)*(sin(Wss)-sin(Wsr)))+(cos(delta)*cos(gamma)*sin(fee)*sin(beta)*(sin(Wss)-sin
(Wsr)))-(cos(delta)*sin(beta)*sin(gamma)*(cos(Wss)-cos(Wsr))))/(2*(cos(fee)*cos(delta)*sin(Ws)+Ws*sin
(fee)*sin(delta)));

elseif gamma_w1<0
 gamma= gamma_w1;
 beta   = beta_w;
 A      = cos(fee)/(sin(gamma)*tan(beta))+sin(fee)/tan(gamma);
 B      = tan(delta)*(cos(fee)/tan(gamma)-sin(fee)/(sin(gamma)*tan(beta)));
 Wsr1   = Ws;
 Wsr2   = acos((A*B-(A^2-B^2+1)^(1/2))/(A^2+1));
 if Wsr1<Wsr2
   Wsr  = -Wsr1;
 elseif Wsr2<Wsr1
   Wsr  = -Wsr2;
 end
```

```
  Wss1     = Ws;
  Wss2     = acos((A*B+(A^2-B^2+1)^(1/2))/(A^2+1));
  if Wss1<Wss2
    Wss   = Wss1;
  elseif Wss2<Wss1
    Wss   = Wss2;
  end
  Rb_w1    = ((cos(beta)*sin(delta)*sin(fee)*(Wss-Wsr))-(sin(delta)*cos(fee)*sin(beta)*cos(gamma)*(Wss-Wsr))+
(cos(fee)*cos(delta)*cos(beta)*(sin(Wss)-sin(Wsr)))+(cos(delta)*cos(gamma)*sin(fee)*sin(beta)*(sin(Wss)-sin
(Wsr)))-(cos(delta)*sin(beta)*sin(gamma)*(cos(Wss)-cos(Wsr))))/(2*(cos(fee)*cos(delta)*sin(Ws)+Ws*sin
(fee)*sin(delta)));
elseif gamma_w1==0
  gamma = gamma_w1;
  beta     = beta_w;
  Wsp1    = acos(-tan(fee)*tan(delta));
  Wsp2    = acos(-tan(fee-beta)*tan(delta));
  if Wsp1<Wsp2
    Wsp   = Wsp1;
  elseif Wsp2<Wsp1
    Wsp   = Wsp2;
  end
  Rb_w1  = (cos(fee-beta)*cos(delta)*sin(Wsp)+Wsp*sin(fee-beta)*sin(delta))/(cos(fee)*cos(delta)*sin
(Ws)+Ws*sin(fee)*sin(delta));
end
Ht_w1     = H*(1-Hd/H)*Rb_w1+Hd*(1+cos(beta_w))/2+low*H*(1-cos(beta_w))/2;
It_w1      = rt*Ht_w1;
Qabsorp_w1  = absorp_w*It_w1/3600;
if gamma_w2>0
  gamma = gamma_w2;
  beta     = beta_w;
  A          = cos(fee)/(sin(gamma)*tan(beta))+sin(fee)/tan(gamma);
  B          = tan(delta)*(cos(fee)/tan(gamma)-sin(fee)/(sin(gamma)*tan(beta)));
```

```
Wsr1  = Ws;
Wsr2  = acos((A*B+(A^2-B^2+1)^(1/2))/(A^2+1));
if Wsr1<Wsr2
  Wsr  = -Wsr1;
elseif Wsr2<Wsr1
  Wsr  = -Wsr2;
end
Wss1    = Ws;
Wss2    = acos((A*B-(A^2-B^2+1)^(1/2))/(A^2+1));
if Wss1<Wss2
  Wss  = Wss1;
elseif Wss2<Wss1
  Wss  = Wss2;
end
Rb_w2 = ((cos(beta)*sin(delta)*sin(fee)*(Wss-Wsr))-(sin(delta)*cos(fee)*sin(beta)*cos(gamma)*(Wss-Wsr))+
(cos(fee)*cos(delta)*cos(beta)*(sin(Wss)-sin(Wsr)))+(cos(delta)*cos(gamma)*sin(fee)*sin(beta)*(sin(Wss)-sin
(Wsr)))-(cos(delta)*sin(beta)*sin(gamma)*(cos(Wss)-cos(Wsr))))/(2*(cos(fee)*cos(delta)*sin(Ws)+Ws*sin
(fee)*sin(delta)));
elseif gamma_w2<0
 gamma = gamma_w2;
 beta    = beta_w;
 A       = cos(fee)/(sin(gamma)*tan(beta))+sin(fee)/tan(gamma);
 B       = tan(delta)*(cos(fee)/tan(gamma)-sin(fee)/(sin(gamma)*tan(beta)));
 Wsr1  = Ws;
 Wsr2  = acos((A*B-(A^2-B^2+1)^(1/2))/(A^2+1));
 if Wsr1<Wsr2
   Wsr  = -Wsr1;
 elseif Wsr2<Wsr1
   Wsr  = -Wsr2;
 end
 Wss1    = Ws;
 Wss2    = acos((A*B+(A^2-B^2+1)^(1/2))/(A^2+1));
```

```
  if Wss1<Wss2
    Wss   = Wss1;
  elseif Wss2<Wss1
    Wss   = Wss2;
  end
  Rb_w2   = ((cos(beta)*sin(delta)*sin(fee)*(Wss-Wsr))-(sin(delta)*cos(fee)*sin(beta)*cos(gamma)*(Wss-Wsr))+
(cos(fee)*cos(delta)*cos(beta)*(sin(Wss)-sin(Wsr)))+(cos(delta)*cos(gamma)*sin(fee)*sin(beta)*(sin(Wss)-sin
(Wsr)))-(cos(delta)*sin(beta)*sin(gamma)*(cos(Wss)-cos(Wsr))))/(2*(cos(fee)*cos(delta)*sin(Ws)+Ws*sin
(fee)*sin(delta)));
elseif gamma_w2==0
  gamma = gamma_w2;
  beta    = beta_w;
  Wsp1   = acos(-tan(fee)*tan(delta));
  Wsp2   = acos(-tan(fee-beta)*tan(delta));
  if Wsp1<Wsp2
    Wsp   = Wsp1;
  elseif Wsp2<Wsp1
    Wsp   = Wsp2;
  end
  Rb_w2   = (cos(fee-beta)*cos(delta)*sin(Wsp)+Wsp*sin(fee-beta)*sin(delta))/(cos(fee)*cos(delta)*sin
(Ws)+Ws*sin(fee)*sin(delta));
end
Ht_w2     = H*(1-Hd/H)*Rb_w2+Hd*(1+cos(beta_w))/2+low*H*(1-cos(beta_w))/2;
It_w2     = rt*Ht_w2;
Qabsorp_w2 = absorp_w*It_w2/3600;
Time=[1:1:k];
for i=1:k-1;
  i=i+1;
  Ws(i)     = acos(-tan(fee)*tan(delta));
     aa(i)  = 0.514+0.228.*sin((Ws(i).*180/pi-60).*pi/180);
     bb(i)  = 0.512+0.083.*sin((Ws(i).*180/pi-60).*pi/180);
```

```
    if j==1|j==2|j==3|j==4|j==5|j==6|j==7|j==8|j==9|j==10|j==11|j==12
    W(i) = -90*pi/180;
    elseif j==13|j==14|j==15|j==16|j==17|j==18|j==19|j==20|j==21|j==22|j==23|j==24
    W(i) = -75*pi/180;
    elseif j==25|j==26|j==27|j==28|j==29|j==30|j==31|j==32|j==33|j==34|j==35|j==36
    W(i) = -60*pi/180;
    elseif j==37|j==38|j==39|j==40|j==41|j==42|j==43|j==44|j==45|j==46|j==47|j==48
    W(i) = -45*pi/180;
    elseif j==49|j==50|j==51|j==52|j==53|j==54|j==55|j==56|j==57|j==58|j==59|j==60
    W(i) = -30*pi/180;
    elseif j==61|j==62|j==63|j==64|j==65|j==66|j==67|j==68|j==69|j==70|j==71|j==72
    W(i) = -15*pi/180;
    elseif j==73|j==74|j==75|j==76|j==77|j==78|j==79|j==80|j==81|j==82|j==83|j==84
    W(i) = 0*pi/180;
    elseif j==85|j==86|j==87|j==88|j==89|j==90|j==91|j==92|j==93|j==94|j==95|j==96
    W(i) = 15*pi/180;
    elseif j==97|j==98|j==99|j==100|j==101|j==102|j==103|j==104|j==105|j==106|j==107|j==108
    W(i) = 30*pi/180;
    elseif j==109|j==110|j==111|j==112|j==113|j==114|j==115|j==116|j==117|j==118|j==119|j==120
    W(i) = 45*pi/180;
    elseif j==121|j==122|j==123|j==124|j==125|j==126|j==127|j==128|j==129|j==130|j==131|j==132
    W(i) = 60*pi/180;
    elseif j==133|j==134|j==135|j==136|j==137|j==138|j==139|j==140|j==141|j==142|j==143|j==144
    W(i) = 75*pi/180;
    elseif j==145|j==146|j==147|j==148|j==149|j==150|j==151|j==152|j==153|j==154|j==155|j==156
    W(i) = 90*pi/180;
    end
rt(i)           = pi/24*(aa(i)+bb(i).*cos(W(i))).*(cos(W(i))-cos(Ws(i)))./(sin(Ws(i))-Ws(i).*cos(Ws(i)));
It_r1(i)        = rt(i)*Ht_r1;
Qabsorp_r1(i)   = absorp_r.*It_r1(i)./3600;
It_r2(i)        = rt(i)*Ht_r2;
Qabsorp_r2(i)   = absorp_r.*It_r2(i)./3600;
```

```
It_w1(i)        = rt(i)*Ht_w1;
Qabsorp_w1(i) = absorp_w.*It_w1(i)./3600;
It_w2(i)        = rt(i)*Ht_w2;
Qabsorp_w2(i) = absorp_w.*It_w2(i)./3600;
end
pQr1         = polyfit(Time,Qabsorp_r1,7);
pQr2         = polyfit(Time,Qabsorp_r2,7);
pQw1         = polyfit(Time,Qabsorp_w1,7);
pQw2         = polyfit(Time,Qabsorp_w2,7);

Tam          = Tenter(1);
Tsky         = 0.0552*Tam^(1.5);
Tin          = input('Tin ')+273.15;
Tinfirst     = Tin;
Tin1         = Tin;
Tro1         = Tam(1)+4;
Tro2         = Tro1+1;
Tri          = Tro1+2;
aaa          = Tro1;
bbb          = Tro2;
ccc          = Tri;
Two1         = Tam(1)+3;
Two2         = Two1+10;
Twi          = Two1+2;

Tinlet       = input('Temp. air leave wet pad ')+273.15;
Qabdel_r1    = input('Qabdel_r1 ');
Qabdel_r2    = input('Qabdel_r2 ');
Qabdel_w1    = input('Qabdel_w1 ');
Qabdel_w2    = input('Qabdel_w2 ');
DeltaQ_r11   = 10;
DeltaQ_r12   = 10;
```

```
DeltaQ_r21   = 10;
DeltaQ_r22   = 10;
DeltaQ_w11   = 10;
DeltaQ_w12   = 10;
DeltaQ_w21   = 10;
DeltaQ_w22   = 10;

Ac_in        = input('Cross section area in swine house');
Va_in        = input('Vair in room ');
Vfp          = input('Vair over flat plate ');
airdensity_in = -3.997e-3*Tinlet+2.3605;
j            = input('start hour angle ');
k            = input('number of point to plot every 5 minute ');
Cp           = 3e-002*Tinlet+9.98e+002;
time         = input('range of time to find temp.')
Qswine       = input('Amout of swine ')*0.132;
while DeltaQ_r11>0.1 | DeltaQ_r11<-0.1
Tfo          = (Tam+Tro1)/2;
kineviscos_Tfo = (9.48e-002*Tfo-1.255e+001)*0.000001;
k_Tfo        = (7.7e-002*Tfo+3.2e+000)*0.001;
Pr_Tfo       = -2.0e-004*Tfo+7.67e-001;
B_Tfo        = 1/Tfo;
Gr_r         = abs(9.81*sin(beta_r1)*B_Tfo*(Tro1-Tam)*(L_r^3))/(kineviscos_Tfo^2);
Ra_v         = Gr_r*Pr_Tfo;
Nu_vo        = (0.825+((0.387*Ra_v^(1/6))/(1+(0.492/Pr_Tfo)^(9/16))^(8/27)))^2;
hc_ro        = Nu_vo*k_Tfo/L_r;
hr           = 5.67e-8*Emissivity_r*(Tsky+Tro1)*(Tsky^2+Tro1^2);
Q_r11        = hr*(Tsky-Tro1)+hc_ro*(Tam-Tro1)+abs(Qabdel_r1);
Tri          = Tro1-Q_r11*(thick_r/k_r);
Tfi          = (Tri+Tin)/2;
kineviscos_Tfi = (9.48e-002*Tfi-1.255e+001)*0.000001;
k_Tfi        = (7.7e-002*Tfi+3.2e+000)*0.001;
```

```
Pr_Tfi        = -2.0e-004*Tfi+7.67e-001;
B_Tfi         = 1/Tfi;
Re_r          = Vfp*L_r/kineviscos_Tfi;
if Re_r<5e+5
  Nu_ri       = 0.664*Pr_Tfi^(1/3)*Re_r^(1/2);
elseif Re_r>5e+5 & Re_r<5.5e+6
  Nu_ri       = 0.036*Pr_Tfi^(0.43)*(Re_r^(0.8)-9200);
else
  disp('Renolds number not in the range ');
end
hc_ri         = Nu_ri*k_Tfi/L_r;
Q_r12         = (Tri-Tin)/(1/hc_ri);
DeltaQ_r11    = Q_r11-Q_r12;
    if DeltaQ_r11<-0.1 | DeltaQ_r11>0.1
    Tfo           = (Tam+Tro2)/2;
     kineviscos_Tfo = (9.48e-002*Tfo-1.255e+001)*0.000001;
    k_Tfo         = (7.7e-002*Tfo+3.2e+000)*0.001;
    Pr_Tfo        = -2.0e-004*Tfo+7.67e-001;
    B_Tfo         = 1/Tfo;
     Gr_r         = abs(9.81*sin(beta_r1)*B_Tfo*(Tro2-Tam)*(L_r^3))/(kineviscos_Tfo^2);
    Ra_v          = Gr_r*Pr_Tfo;
    Nu_vo         = (0.825+((0.387*Ra_v^(1/6))/(1+(0.492/Pr_Tfo)^(9/16))^(8/27)))^2;
    hc_ro         = Nu_vo*k_Tfo/L_r;
    hr            = 5.67e-8*Emissivity_r*(Tsky+Tro2)*(Tsky^2+Tro2^2);
    Q_r13         = hr*(Tsky-Tro2)+hc_ro*(Tam-Tro2)+abs(Qabdel_r1);
    Tri           = Tro2-Q_r13*(thick_r/k_r);
    Tfi           = (Tri+Tin)/2;
    kineviscos_Tfi = (9.48e-002*Tfi-1.255e+001)*0.000001;
    k_Tfi         = (7.7e-002*Tfi+3.2e+000)*0.001;
    Pr_Tfi        = -2.0e-004*Tfi+7.67e-001;
    B_Tfi         = 1/Tfi;
    Re_r          = Vfp*L_r/kineviscos_Tfi;
```

```
            if Re_r<5e+5
                  Nu_ri = 0.664*Pr_Tfi^(1/3)*Re_r^(1/2);
            elseif Re_r>5e+5 & Re_r<5.5e+6
                  Nu_ri = 0.036*Pr_Tfi^(0.43)*(Re_r^(0.8)-9200);
            else
                  disp('Renolds number not in the range ');
            end
   hc_ri     = Nu_ri*k_Tfi/L_r;
   Q_r14     = (Tri-Tin)/(1/hc_ri);
   DeltaQ_r12  = Q_r13-Q_r14;
   x         = [DeltaQ_r11,DeltaQ_r12];
   y         = [Tro1,Tro2];
   p         = polyfit(x,y,1);
   z         = polyval(p,0);
   Tro2      = Tro1;
   Tro1      = z;
     end
end
dd   = Tro1;
ee   = Tro2;
ff   = Tri;
Tro1 = aaa;
Tro2 = bbb;
Tri  = ccc;
while DeltaQ_r21>0.1 | DeltaQ_r21<-0.1
Tfo             = (Tam+Tro1)/2;
kineviscos_Tfo  = (9.48e-002*Tfo-1.255e+001)*0.000001;
k_Tfo           = (7.7e-002*Tfo+3.2e+000)*0.001;
Pr_Tfo          = -2.0e-004*Tfo+7.67e-001;
B_Tfo           = 1/Tfo;
Gr_r            = abs(9.81*sin(beta_r2)*B_Tfo*(Tro1-Tam)*(L_r^3))/(kineviscos_Tfo^2);
Ra_v            = Gr_r*Pr_Tfo;
```

```
Nu_vo        = (0.825+((0.387*Ra_v^(1/6))/(1+(0.492/Pr_Tfo)^(9/16))^(8/27)))^2;
hc_ro        = Nu_vo*k_Tfo/L_r;
hr           = 5.67e-8*Emissivity_r*(Tsky+Tro1)*(Tsky^2+Tro1^2);
Q_r21        = hr*(Tsky-Tro1)+hc_ro*(Tam-Tro1)+abs(Qabdel_r2);
Tri          = Tro1-Q_r21*(thick_r/k_r);
Tfi          = (Tri+Tin)/2;
kineviscos_Tfi = (9.48e-002*Tfi-1.255e+001)*0.000001;
k_Tfi        = (7.7e-002*Tfi+3.2e+000)*0.001;
Pr_Tfi       = -2.0e-004*Tfi+7.67e-001;
B_Tfi        = 1/Tfi;
Re_r         = Vfp*L_r/kineviscos_Tfi;
if Re_r<5e+5
  Nu_ri      = 0.664*Pr_Tfi^(1/3)*Re_r^(1/2);
elseif Re_r>5e+5 & Re_r<5.5e+6
  Nu_ri      = 0.036*Pr_Tfi^(0.43)*(Re_r^(0.8)-9200);
else
  disp('Renolds number not in the range');
end
hc_ri        = Nu_ri*k_Tfi/L_r;
Q_r22        = (Tri-Tin)/(1/hc_ri);
DeltaQ_r21     = Q_r21-Q_r22;
    if DeltaQ_r21<-0.1 | DeltaQ_r21>0.1
    Tfo          = (Tam+Tro2)/2;
    kineviscos_Tfo  = (9.48e-002*Tfo-1.255e+001)*0.000001;
    k_Tfo        = (7.7e-002*Tfo+3.2e+000)*0.001;
    Pr_Tfo       = -2.0e-004*Tfo+7.67e-001;
    B_Tfo        = 1/Tfo;
    Gr_r         = abs(9.81*sin(beta_r2)*B_Tfo*(Tro2-Tam)*(L_r^3))/(kineviscos_Tfo^2);
    Ra_v         = Gr_r*Pr_Tfo;
    Nu_vo        = (0.825+((0.387*Ra_v^(1/6))/(1+(0.492/Pr_Tfo)^(9/16))^(8/27)))^2;
    hc_ro        = Nu_vo*k_Tfo/L_r;
    hr           = 5.67e-8*Emissivity_r*(Tsky+Tro2)*(Tsky^2+Tro2^2);
```

```
    Q_r23         = hr*(Tsky-Tro2)+hc_ro *(Tam-Tro2)+abs(Qabdel_r2);
    Tri           = Tro2-Q_r23*(thick_r/k_r);
    Tfi           = (Tri+Tin)/2;
    kineviscos_Tfi = (9.48e-002*Tfi-1.255e+001)*0.000001;
    k_Tfi         = (7.7e-002*Tfi+3.2e+000)*0.001;
    Pr_Tfi        = -2.0e-004*Tfi+7.67e-001;
    B_Tfi         = 1/Tfi;
    Re_r          = Vfp*L_r/kineviscos_Tfi;
        if Re_r<5e+5
            Nu_ri   = 0.664*Pr_Tfi^(1/3)*Re_r^(1/2);
        elseif Re_r>5e+5 & Re_r<5.5e+6
            Nu_ri   = 0.036*Pr_Tfi^(0.43)*(Re_r^(0.8)-9200);
        else
            disp('Renolds number not in the range');
        end
   hc_ri      = Nu_ri*k_Tfi/L_r;
   Q_r24      = (Tri-Tin)/(1/hc_ri);
   DeltaQ_r22= Q_r23-Q_r24;
   x          = [DeltaQ_r21,DeltaQ_r22];
   y          = [Tro1,Tro2];
   p          = polyfit(x,y,1);
   z          = polyval(p,0);
   Tro2       = Tro1;
   Tro1       = z;
   end
end
gg = Tro1;
hh = Tro2;
ii  = Tri;
while DeltaQ_w11>0.1 | DeltaQ_w11<-0.1
Tfo           = (Tam+Two1)/2;
kineviscos_Tfo  = (9.48e-002*Tfo-1.255e+001)*0.000001;
```

```
k_Tfo       = (7.7e-002*Tfo+3.2e+000)*0.001;
Pr_Tfo      = -2.0e-004*Tfo+7.67e-001;
B_Tfo       = 1/Tfo;
Gr_w        = abs(9.81*B_Tfo*(Two1-Tam)*(L_w^3))/(kineviscos_Tfo^2);
Ra_v        = Gr_w*Pr_Tfo;
Nu_vo       = (0.825+((0.387*Ra_v^(1/6))/(1+(0.492/Pr_Tfo)^(9/16))^(8/27)))^2;
hc_wo       = Nu_vo*k_Tfo/L_w;
hr          = 5.67e-8*Emissivity_w*(Tsky+Two1)*(Tsky^2+Two1^2);
Q_w11       = hr*(Tsky-Two1)+hc_wo*(Tam-Two1)+Qabdel_w1(1);
Twi         = Two1-Q_w11*(thick_w/k_w);
Tfi         = (Twi+Tin)/2;
kineviscos_Tfi = (9.48e-002*Tfi-1.255e+001)*0.000001;
k_Tfi       = (7.7e-002*Tfi+3.2e+000)*0.001;
Pr_Tfi      = -2.0e-004*Tfi+7.67e-001;
B_Tfi       = 1/Tfi;
Re_w        = Vfp*L_w/kineviscos_Tfi;
if Re_w<5e+5
  Nu_wi     = 0.664*Pr_Tfi^(1/3)*Re_w^(1/2);
elseif Re_w>5e+5 & Re_w<5.5e+6
  Nu_wi     = 0.036*Pr_Tfi^(0.43)*(Re_w^(0.8)-9200);
else
  disp('Renolds number not in the range ');
end
hc_wi       = Nu_wi*k_Tfi/L_w;
Q_w12       = (Twi-Tin)/(1/hc_wi);
DeltaQ_w11  = Q_w11-Q_w12;
    if DeltaQ_w11<-0.1 | DeltaQ_w11>0.1
    Tfo       = (Tam+Two2)/2;
    kineviscos_Tfo = (9.48e-002*Tfo-1.255e+001)*0.000001;
    k_Tfo     = (7.7e-002*Tfo+3.2e+000)*0.001;
    Pr_Tfo    = -2.0e-004*Tfo+7.67e-001;
    B_Tfo     = 1/Tfo;
```

```
Gr_w        = abs(9.81*B_Tfo*(Two2-Tam)*(L_w^3))/(kineviscos_Tfo^2);
Ra_v        = Gr_w*Pr_Tfo;
Nu_vo       = (0.825+((0.387*Ra_v^(1/6))/(1+(0.492/Pr_Tfo)^(9/16))^(8/27)))^2;
hc_wo          = Nu_vo*k_Tfo/L_w;
hr             = 5.67e-8*Emissivity_w*(Tsky+Two2)*(Tsky^2+Two2^2);
Q_w13          = hr*(Tsky-Two2)+hc_wo*(Tam-Two2)+Qabdel_w1(1);
Twi            = Two2-Q_w13*(thick_w/k_w);
Tfi            = (Twi+Tin)/2;
kineviscos_Tfi = (9.48e-002*Tfi-1.255e+001)*0.000001;
k_Tfi        = (7.7e-002*Tfi+3.2e+000)*0.001;
Pr_Tfi        = -2.0e-004*Tfi+7.67e-001;
B_Tfi         = 1/Tfi;
Re_w          = Vfp*L_w/kineviscos_Tfi;
     if Re_w<5e+5
          Nu_wi     = 0.664*Pr_Tfi^(1/3)*Re_w^(1/2);
     elseif Re_w>5e+5 & Re_w<5.5e+6
          Nu_wi     = 0.036*Pr_Tfi^(0.43)*(Re_w^(0.8)-9200);
     else
          disp('Renolds number not in the range ');
     end
hc_wi       = Nu_wi*k_Tfi/L_w;
Q_w14       = (Twi-Tin)/(1/hc_wi);
DeltaQ_w12  = Q_w13-Q_w14;
x           = [DeltaQ_w11,DeltaQ_w12];
y           = [Two1,Two2];
p           = polyfit(x,y,1);
z           = polyval(p,0);
Two2        = Two1;
Two1        = z;
   end
end
mm = Two1;
```

```
nn  = Two2;
oo  = Twi;
while DeltaQ_w21>0.1 | DeltaQ_w21<-0.1
Tfo             = (Tam+Two1)/2;
kineviscos_Tfo = (9.48e-002*Tfo-1.255e+001)*0.000001;
k_Tfo          = (7.7e-002*Tfo+3.2e+000)*0.001;
Pr_Tfo         = -2.0e-004*Tfo+7.67e-001;
B_Tfo          = 1/Tfo;
Gr_w           = abs(9.81*B_Tfo*(Two1-Tam)*(L_w^3))/(kineviscos_Tfo^2);
Ra_v           = Gr_w*Pr_Tfo;
Nu_vo          = (0.825+((0.387*Ra_v^(1/6))/(1+(0.492/Pr_Tfo)^(9/16))^(8/27)))^2;
hc_wo          = Nu_vo*k_Tfo/L_w;
hr             = 5.67e-8*Emissivity_w*(Tsky+Two1)*(Tsky^2+Two1^2);
Q_w21          = hr*(Tsky-Two1)+hc_wo*(Tam-Two1)+Qabdel_w2(1);
Twi             = Two1-Q_w21*(thick_w/k_w);
Tfi             = (Twi+Tin)/2;
kineviscos_Tfi = (9.48e-002*Tfi-1.255e+001)*0.000001;
k_Tfi          = (7.7e-002*Tfi+3.2e+000)*0.001;
Pr_Tfi         = -2.0e-004*Tfi+7.67e-001;
B_Tfi          = 1/Tfi;
Re_w           = Vfp*L_w/kineviscos_Tfi;
if Re_w<5e+5
  Nu_wi       = 0.664*Pr_Tfi^(1/3)*Re_w^(1/2);
elseif Re_w>5e+5 & Re_w<5.5e+6
  Nu_wi       = 0.036*Pr_Tfi^(0.43)*(Re_w^(0.8)-9200);
else
  disp('Renolds number not in the range ');
end
hc_wi           = Nu_wi*k_Tfi/L_w;
Q_w22           = (Twi-Tin)/(1/hc_wi);
DeltaQ_w21  = Q_w21-Q_w22;
     if DeltaQ_w21<-0.1 | DeltaQ_w21>0.1
```

```
Tfo          = (Tam+Two2)/2;
kineviscos_Tfo = (9.48e-002*Tfo-1.255e+001)*0.000001;
k_Tfo        = (7.7e-002*Tfo+3.2e+000)*0.001;
Pr_Tfo       = -2.0e-004*Tfo+7.67e-001;
B_Tfo        = 1/Tfo;
Gr_w         = abs(9.81*B_Tfo*(Two2-Tam)*(L_w^3))/(kineviscos_Tfo^2);
Ra_v         = Gr_w*Pr_Tfo;
Nu_vo        = (0.825+((0.387*Ra_v^(1/6))/(1+(0.492/Pr_Tfo)^(9/16))^(8/27)))^2;
hc_wo        = Nu_vo*k_Tfo/L_w;
hr           = 5.67e-8*Emissivity_w*(Tsky+Two2)*(Tsky^2+Two2^2);
Q_w23        = hr*(Tsky-Two2)+hc_wo*(Tam-Two2)+Qabdel_w2(1);
Twi          = Two2-Q_w23*(thick_w/k_w);
Tfi          = (Twi+Tin)/2;
kineviscos_Tfi = (9.48e-002*Tfi-1.255e+001)*0.000001;
k_Tfi        = (7.7e-002*Tfi+3.2e+000)*0.001;
Pr_Tfi       = -2.0e-004*Tfi+7.67e-001;
B_Tfi        = 1/Tfi;
Re_w         = Vfp*L_w/kineviscos_Tfi;
   if Re_w<5e+5
   Nu_wi   = 0.664*Pr_Tfi^(1/3)*Re_w^(1/2);
   elseif Re_w>5e+5 & Re_w<5.5e+6
   Nu_wi   = 0.036*Pr_Tfi^(0.43)*(Re_w^(0.8)-9200);
   else
   disp('Renolds number not in the range ');
   end
hc_wi        = Nu_wi*k_Tfi/L_w;
Q_w24        = (Twi-Tin)/(1/hc_wi);
DeltaQ_w22 = Q_w23-Q_w24;
x            = [DeltaQ_w21,DeltaQ_w22];
y            = [Two1,Two2];
p            = polyfit(x,y,1);
z            = polyval(p,0);
```

```
  Two2          = Two1;
  Two1          = z;
  end
end
pp=Two1;
qq=Two2;
rr =Twi;
Qvent          = m_rate*Cp*(Tinlet-Tin);
Qtotal         = Q_r11*A_r1+Q_w11*A_w1+Q_w21*A_w2+Q_r21*A_r2+Qvent+Qswine;
Tin            = Qtotal/(m_rate*Cp)+Tin;

Tro1(1)   = Tro1;
Tro2(1)   = Tro1+10;
Tri(1)    = Tri;
Two1(1)   = Two1;
Two2(1)   = Two1+5;
Twi(1)    = Twi;
Tin(1)    = Tin;
dd(1)     = dd;
ee(1)     = ee;
ff(1)     = ff;
gg(1)     = gg;
hh(1)     = hh;
ii(1)     = ii;
mm(1)     = mm;
nn(1)     = nn;
oo(1)     = oo;
pp(1)     = pp;
qq(1)     = qq;
rr(1)     = rr;
```

```
Tam        = Tenter-273;
Time       = [1:1:k];

Qabsorp_r1    = pQr1(1)*Time(1).^7+pQr1(2)*Time(1).^6+pQr1(3)*Time(1).^5+pQr1(4)*Time(1).^4+pQr1
(5)*Time(1).^3+pQr1(6)*Time(1).^2+pQr1(7)*Time(1).^1+pQr1(8);
Qabsorp_r2    = pQr2(1)*Time(1).^7+pQr2(2)*Time(1).^6+pQr2(3)*Time(1).^5+pQr2(4)*Time(1).^4+pQr2
(5)*Time(1).^3+pQr2(6)*Time(1).^2+pQr2(7)*Time(1).^1+pQr2(8);
Qabsorp_w1    = pQw1(1)*Time(1).^7+pQw1(2)*Time(1).^6+pQw1(3)*Time(1).^5+pQw1(4)*Time(1).^4+pQw1
(5)*Time(1).^3+pQw1(6)*Time(1).^2+pQw1(7)*Time(1).^1+pQw1(8);
Qabsorp_w2    = pQw2(1)*Time(1).^7+pQw2(2)*Time(1).^6+pQw2(3)*Time(1).^5+pQw2(4)*Time(1).^4+pQw2
(5)*Time(1).^3+pQw2(6)*Time(1).^2+pQw2(7)*Time(1).^1+pQw2(8);

for i=1:k-1
    i=i+1;
    j=j+1;
    Tam(i)      = Tam(i)+273.15;
    Tsky(i)     = 0.0552*Tam(i).^1.5;
    Tinlet(i)   = Tleave1(i);

  Qabsorp_r1(i)    = pQr1(1)*Time(i).^7+pQr1(2)*Time(i).^6+pQr1(3)*Time(i).^5+pQr1(4)*Time(i).^4+pQr1
(5)*Time(i).^3+pQr1(6)*Time(i).^2+pQr1(7)*Time(i).^1+pQr1(8);
  Qabsorp_r2(i)    = pQr2(1)*Time(1).^7+pQr2(2)*Time(1).^6+pQr2(3)*Time(1).^5+pQr2(4)*Time(1).^4+pQr2
(5)*Time(1).^3+pQr2(6)*Time(1).^2+pQr2(7)*Time(1).^1+pQr2(8);
  Qabsorp_w1(i)    = pQw1(1)*Time(i).^7+pQw1(2)*Time(i).^6+pQw1(3)*Time(i).^5+pQw1(4)*Time
(i).^4+pQw1(5)*Time(i).^3+pQw1(6)*Time(i).^2+pQw1(7)*Time(i).^1+pQw1(8);
  Qabsorp_w2(i)    = pQw2(1)*Time(i).^7+pQw2(2)*Time(i).^6+pQw2(3)*Time(i).^5+pQw2(4)*Time
(i).^4+pQw2(5)*Time(i).^3+pQw2(6)*Time(i).^2+pQw2(7)*Time(i).^1+pQw2(8);

Qabdel_r1(i)     = Qabsorp_r1(i);
Qabdel_r2(i)     = Qabsorp_r2(i);
  if Qabsorp_w1(i)<Qabsorp_w1(i-1)
    Qabdel_w1(i)     = Qabsorp_w1(i);
```

```
  else Qabdel_w1(i)= 0;
end
if Qabsorp_w2(i)>Qabsorp_w2(i-1)
  Qabdel_w2(i)     = Qabsorp_w2(i);
   else Qabdel_w2(i)= 0;
end
DeltaQ_r11(i)  = 10;
DeltaQ_r12(i)  = 10;
DeltaQ_r21(i)  = 10;
DeltaQ_r22(i)  = 10;
DeltaQ_w11(i) = 10;
DeltaQ_w12(i) = 10;
DeltaQ_w21(i)  = 10;
DeltaQ_w22(i)  = 10;

Tro1(i)       = Tro1(i-1);
Tro2(i)       = Tro2(i-1);
Tri(i)        = Tri(i-1);
Two1(i)       = Two1(i-1);
Two2(i)       = Two2(i-1);
Twi(i)        = Twi(i-1);
Tin(i)        = Tin(i-1);

dd(i)         = dd(i-1);
ee(i)         = ee(i-1);
ff(i)         = ff(i-1);
gg(i)         = gg(i-1);
hh(i)         = hh(i-1);
ii(i)         = ii(i-1);
mm(i)         = mm(i-1);
nn(i)         = nn(i-1);
oo(i)         = oo(i-1);
```

```
pp(i)        = pp(i-1);
qq(i)        = qq(i-1);
rr(i)        = rr(i-1);

airdensity_in(i)  = -3.997e-3.*Tinlet(i)+2.3605;
m_rate(i)         = airdensity_in(i).*Ac_in.*Va_in;
Cp(i)             = 3e-002.*Tinlet(i)+9.98e+002;
Tro1(i) = dd(i) ;
Tro2(i)  = ee(i);
Tri(i)   = ff(i);
   while DeltaQ_r11(i)>0.1 | DeltaQ_r11(i)<-0.1
   Tfo(i)            = (Tam(i)+Tro1(i))./2;
   kineviscos_Tfo(i)  = (9.48e-002.*Tfo(i)-1.255e+001)*0.000001;
   k_Tfo(i)          = (7.7e-002.*Tfo(i)+3.2e+000)*0.001;
   Pr_Tfo(i)         = -2.0e-004.*Tfo(i)+7.67e-001;
   B_Tfo(i)          = 1./Tfo(i);
   Gr_r(i)           = abs(9.81*sin(beta_r1).*B_Tfo(i).*(Tro1(i)-Tam(i)).*(L_r^3))./(kineviscos_Tfo(i).^2);
   Ra_r(i)           = Gr_r(i).*Pr_Tfo(i);
   Nu_ro(i)          = (0.825+((0.387*Ra_r(i).^(1/6))./(1+(0.492./Pr_Tfo(i)).^(9/16)).^(8/27))).^2;
   hc_ro(i)          = Nu_ro(i).*k_Tfo(i)./L_r;
   hr(i)             = 5.67e-8*Emissivity_r*(Tsky(i)+Tro1(i)).*(Tsky(i).^2+Tro1(i).^2);
   Q_r11(i)          = hr(i).*(Tsky(i)-Tro1(i))+hc_ro(i).*(Tam(i)-Tro1(i))+abs(Qabdel_r1(i));
   Tri(i)            = Tro1(i)-Q_r11(i)*(thick_r/k_r);
   Tfi(i)            = (Tri(i)+Tin(i))/2;
   kineviscos_Tfi(i)  = (9.48e-002*Tfi(i)-1.255e+001)*0.000001;
   k_Tfi(i)          = (7.7e-002*Tfi(i)+3.2e+000)*0.001;
   Pr_Tfi(i)         = -2.0e-004*Tfi(i)+7.67e-001;
   B_Tfi(i)          = 1./Tfi(i);
   Re_r(i)           = Vfp*L_r./kineviscos_Tfi(i);
   if Re_r(i)<5e+5
   Nu_ri(i)          = 0.664*Pr_Tfi(i).^(1/3).*Re_r(i).^(1/2);
   elseif Re_r(i)>5e+5 & Re_r(i)<5.5e+6
```

```
Nu_ri(i)        = 0.036*Pr_Tfi(i).^(0.43).*(Re_r(i).^(0.8)-9200);
else
disp('Renolds number not in the range ');
end
hc_ri(i)        = Nu_ri(i).*k_Tfi (i)./L_r;
Q_r12(i)        = (Tri(i)-Tin(i))./(1./hc_ri(i));
DeltaQ_r11(i)  = Q_r11(i)-Q_r12(i);
    if DeltaQ_r11(i)<-0.1 | DeltaQ_r11(i)>0.1
    Tfo(i)            = (Tam(i)+Tro2(i))./2;
    kineviscos_Tfo(i)  = (9.48e-002*Tfo(i)-1.255e+001)*0.000001;
    k_Tfo(i)          = (7.7e-002*Tfo(i)+3.2e+000)*0.001;
    Pr_Tfo(i)         = -2.0e-004*Tfo(i)+7.67e-001;
    B_Tfo(i)          = 1./Tfo(i);
    Gr_r(i)           = abs(9.81*sin(beta_r1)*B_Tfo(i).*(Tro2(i)-Tam(i)).*(L_r^3))./(kineviscos_Tfo(i).^2);
    Ra_r(i)           = Gr_r(i).*Pr_Tfo(i);
    Nu_ro(i)          = (0.825+((0.387*Ra_r(i).^(1/6))./(1+(0.492./Pr_Tfo(i)).^(9/16)).^(8/27))).^2;
    hc_ro(i)          = Nu_ro(i).*k_Tfo(i)/L_r;
    hr(i)             = 5.67e-8*Emissivity_r*(Tsky(i)+Tro2(i)).*(Tsky(i).^2+Tro2(i).^2);
    Q_r13(i)          = hr(i).*(Tsky(i)-Tro2(i))+hc_ro(i).*(Tam(i)-Tro2(i))+abs(Qabdel_r1(i));
    Tri(i)            = Tro2(i)-Q_r13(i)*(thick_r/k_r);
    Tfi(i)            = (Tri(i)+Tin(i))/2;
    kineviscos_Tfi(i)  = (9.48e-002*Tfi(i)-1.255e+001)*0.000001;
    k_Tfi(i)          = (7.7e-002*Tfi(i)+3.2e+000)*0.001;
    Pr_Tfi(i)         = -2.0e-004*Tfi(i)+7.67e-001;
    B_Tfi(i)          = 1/Tfi(i);
    Re_r(i)           = Vfp*L_r/kineviscos_Tfi(i);
        if Re_r(i)<5e+5
        Nu_ri(i)      = 0.664*Pr_Tfi(i).^(1/3).*Re_r(i).^(1/2);
        elseif Re_r(i)>5e+5 & Re_r(i)<5.5e+6
        Nu_ri(i)      = 0.036*Pr_Tfi(i).^(0.43).*(Re_r(i).^(0.8)-9200);
        else
        disp('Renolds number not in the range ');
```

```
            end
    hc_ri(i)         = Nu_ri(i).*k_Tfi(i)/L_r;
    Q_r14(i)         = (Tri(i)-Tin(i))./(1/hc_ri(i));
    DeltaQ_r12(i)    = Q_r13(i)-Q_r14(i);
    m(i)             = (Tro2(i)-Tro1(i))./(DeltaQ_r12(i)-DeltaQ_r11(i));
    c(i)             = Tro1(i)-m(i)*DeltaQ_r11(i);
    x(i)             = c(i);
    Tro2(i)          = Tro1(i);
    Tro1(i)          = x(i);
        end
end
dd(i)         = Tro1(i) ;
ee(i)         = Tro2(i);
ff(i)         = Tri(i);
Tro1(i)       = gg(i);
Tro2(i)       = hh(i);
Tri(i)        = ii(i);

while DeltaQ_r21(i)>0.1 | DeltaQ_r21(i)<-0.1
    Tfo(i)            = (Tam(i)+Tro1(i))./2;
    kineviscos_Tfo(i) = (9.48e-002*Tfo(i)-1.255e+001)*0.000001;
    k_Tfo(i)          = (7.7e-002*Tfo(i)+3.2e+000)*0.001;
    Pr_Tfo(i)         = -2.0e-004*Tfo(i)+7.67e-001;
    B_Tfo(i)          = 1/Tfo(i);
    Gr_r(i)           = abs(9.81*sin(beta_r2)*B_Tfo(i).*(Tro1(i)-Tam(i)).*(L_r^3))./(kineviscos_Tfo(i).^2);
    Ra_r(i)           = Gr_r(i).*Pr_Tfo(i);
    Nu_ro(i)          = (0.825+((0.387*Ra_r(i).^(1/6))./(1+(0.492/Pr_Tfo(i)).^(9/16)).^(8/27))).^2;
    hc_ro(i)          = Nu_ro(i).*k_Tfo(i)/L_r;
    hr(i)             = 5.67e-8*Emissivity_r*(Tsky(i)+Tro1(i)).*(Tsky(i).^2+Tro1(i).^2);
    Q_r21(i)          = hr(i).*(Tsky(i)-Tro1(i))+hc_ro(i).*(Tam(i)-Tro1(i))+abs(Qabdel_r2(i));
    Tri(i)            = Tro1(i)-Q_r21(i)*(thick_r/k_r);
    Tfi(i)            = (Tri(i)+Tin(i))./2;
```

```
kineviscos_Tfi(i)  = (9.48e-002*Tfi(i)-1.255e+001)*0.000001;
k_Tfi(i)           = (7.7e-002*Tfi(i)+3.2e+000)*0.001;
Pr_Tfi(i)          = -2.0e-004*Tfi(i)+7.67e-001;
B_Tfi(i)           = 1/Tfi(i);
Re_r(i)            = Vfp*L_r/kineviscos_Tfi(i);
if Re_r(i)<5e+5
Nu_ri(i)           = 0.664*Pr_Tfi(i).^(1/3).*Re_r(i).^(1/2);
elseif Re_r(i)>5e+5 & Re_r(i)<5.5e+6
Nu_ri(i)           = 0.036*Pr_Tfi(i).^(0.43).*(Re_r(i).^(0.8)-9200);
else
disp('Renolds number not in the range');
end
hc_ri(i)           = Nu_ri(i).*k_Tfi(i)/L_r;
Q_r22(i)           = (Tri(i)-Tin(i))./(1/hc_ri(i));
DeltaQ_r21(i)  = Q_r21(i)-Q_r22(i);
    if DeltaQ_r21(i)<-0.1 | DeltaQ_r21(i)>0.1
    Tfo(i)          = (Tam(i)+Tro2(i))/2;
    kineviscos_Tfo(i) = (9.48e-002*Tfo(i)-1.255e+001)*0.000001;
    k_Tfo(i)        = (7.7e-002*Tfo(i)+3.2e+000)*0.001;
    Pr_Tfo(i)       = -2.0e-004*Tfo(i)+7.67e-001;
    B_Tfo(i)        = 1/Tfo(i);
    Gr_r(i)         = abs(9.81*sin(beta_r2)*B_Tfo(i).*(Tro2(i)-Tam(i)).*(L_r^3))./(kineviscos_Tfo(i).^2);
    Ra_r(i)         = Gr_r(i).*Pr_Tfo(i);
    Nu_ro(i)        = (0.825+((0.387*Ra_r(i).^(1/6))./(1+(0.492/Pr_Tfo(i)).^(9/16)).^(8/27))).^2;
    hc_ro(i)        = Nu_ro(i).*k_Tfo(i)/L_r;
    hr(i)           = 5.67e-8*Emissivity_r*(Tsky(i)+Tro2(i)).*(Tsky(i).^2+Tro2(i).^2);
    Q_r23(i)        = hr(i).*(Tsky(i)-Tro2(i))+hc_ro(i).*(Tam(i)-Tro2(i))+abs(Qabdel_r2(i));
    Tri(i)          = Tro2(i)-Q_r23(i)*(thick_r/k_r);
    Tfi(i)          = (Tri(i)+Tin(i))/2;
    kineviscos_Tfi(i)= (9.48e-002*Tfi(i)-1.255e+001)*0.000001;
    k_Tfi(i)        = (7.7e-002*Tfi(i)+3.2e+000)*0.001;
    Pr_Tfi(i)       = -2.0e-004*Tfi(i)+7.67e-001;
```

```
        B_Tfi(i)        = 1/Tfi(i);
        Re_r(i)         = Vfp*L_r/kineviscos_Tfi(i);
            if Re_r(i)<5e+5
              Nu_ri(i) = 0.664*Pr_Tfi(i).^(1/3).*Re_r(i).^(1/2);
            elseif Re_r(i)>5e+5 & Re_r(i)<5.5e+6
              Nu_ri(i) = 0.036*Pr_Tfi(i).^(0.43).*(Re_r(i).^(0.8)-9200);
            else
                disp('Renolds number not in the range');
            end
    hc_ri(i)        = Nu_ri(i).*k_Tfi(i)/L_r;
    Q_r24(i)        = (Tri(i)-Tin(i))./(1/hc_ri(i));
    DeltaQ_r22(i)  = Q_r23(i)-Q_r24(i);
    m(i)            = (Tro2(i)-Tro1(i))./(DeltaQ_r22(i)-DeltaQ_r21(i));
    c(i)            = Tro1(i)-m(i)*DeltaQ_r21(i);
    x(i)            = c(i);
   Tro2(i)          = Tro1(i);
   Tro1(i)          = x(i);
     end
end
gg(i)      = Tro1(i) ;
hh(i)      = Tro2(i);
ii(i)      = Tri(i);
Two1(i) = mm(i);
Two2(i) = nn(i);
Twi(i)  = oo(i);
    while DeltaQ_w11(i)>0.1 | DeltaQ_w11(i)<-0.1
    Tfo(i)          = (Tam(i)+Two1(i))/2;
    kineviscos_Tfo(i)= (9.48e-002*Tfo(i)-1.255e+001)*0.000001;
    k_Tfo(i)        = (7.7e-002*Tfo(i)+3.2e+000)*0.001;
    Pr_Tfo(i)       = -2.0e-004*Tfo(i)+7.67e-001;
    B_Tfo(i)        = 1/Tfo(i);
    Gr_w(i)         = abs(9.81*B_Tfo(i).*(Two1(i)-Tam(i))*(L_w^3))./(kineviscos_Tfo(i).^2);
```

```
 Ra_w(i)        = Gr_w(i).*Pr_Tfo(i);
 Nu_wo(i)       = (0.825+((0.387*Ra_w(i).^(1/6))./(1+(0.492/Pr_Tfo(i)).^(9/16)).^(8/27))).^2;
 hc_wo(i)       = Nu_wo(i).*k_Tfo(i)/L_w;
 hr(i)          = 5.67e-8*Emissivity_w*(Tsky(i)+Two1(i)).*(Tsky(i).^2+Two1(i).^2);
Q_w11(i)        = hr(i).*(Tsky(i)-Two1(i))+hc_wo(i).*(Tam(i)-Two1(i))+abs(Qabdel_w1(i));
Twi(i)          = Two1(i)-Q_w11(i)*(thick_w/k_w);
 Tfi(i)         = (Twi(i)+Tin(i))/2;
 kineviscos_Tfi(i) = (9.48e-002*Tfi(i)-1.255e+001)*0.0O0001;
 k_Tfi(i)       = (7.7e-002*Tfi(i)+3.2e+000)*0.001;
 Pr_Tfi(i)      = -2.0e-004*Tfi(i)+7.67e-001;
 B_Tfi(i)       = 1/Tfi(i);
 Re_w(i)        = Vfp*L_w/kineviscos_Tfi(i);
 if Re_w(i)<5e+5
 Nu_wi(i)    =  0.664*Pr_Tfi(i).^(1/3).*Re_w(i).^(1/2);
 elseif Re_w(i)>5e+5 & Re_w(i)<5.5e+6
 Nu_wi(i)    =  0.036*Pr_Tfi(i).^(0.43).*(Re_w(i).^(0.8)-9200);
 else
 disp('Renolds number not in the range ');
 end
 hc_wi(i)       = Nu_wi(i).*k_Tfi(i)/L_w;
Q_w12(i)        = (Twi(i)-Tin(i))./(1/hc_wi(i));
 DeltaQ_w11(i)   = Q_w11(i)-Q_w12(i);
    if DeltaQ_w11(i)<-0.1 | DeltaQ_w11(i)>0.1
    Tfo(i)         = (Tam(i)+Two2(i))/2;
    kineviscos_Tfo(i)= (9.48e-002*Tfo(i)-1.255e+001)*0.000001;
    k_Tfo(i)       = (7.7e-002*Tfo(i)+3.2e+000)*0.001;
    Pr_Tfo(i)      = -2.0e-004*Tfo(i)+7.67e-001;
    B_Tfo(i)       = 1/Tfo(i);
    Gr_w(i)        = abs(9.81*B_Tfo(i).*(Two2(i)-Tam(i))*(L_w^3))./(kineviscos_Tfo(i).^2);
    Ra_w(i)        = Gr_w(i).*Pr_Tfo(i);
    Nu_wo(i)       = (0.825+((0.387*Ra_w(i).^(1/6))./(1+(0.492/Pr_Tfo(i)).^(9/16)).^(8/27))).^2;
    hc_wo(i)       = Nu_wo(i).*k_Tfo(i)/L_w;
```

```
        hr(i)            = 5.67e-8*Emissivity_w*(Tsky(i)+Two2(i)).*(Tsky(i).^2+Two2(i).^2);
        Q_w13(i)         = hr(i).*(Tsky(i)-Two2(i))+hc_wo(i).*(Tam(i)-Two2(i))+abs(Qabdel_w1(i));
        Twi(i)           = Two2(i)-Q_w13(i)*(thick_w/k_w);
        Tfi(i)           = (Twi(i)+Tin(i))/2;
        kineviscos_Tfi(i)= (9.48e-002*Tfi(i)-1.255e+001)*0.000001;
        k_Tfi(i)         = (7.7e-002*Tfi(i)+3.2e+000)*0.001;
        Pr_Tfi(i)        = -2.0e-004*Tfi(i)+7.67e-001;
        B_Tfi(i)         = 1/Tfi(i);
        Re_w(i)          = Vfp*L_w/kineviscos_Tfi(i);
            if Re_w(i)<5e+5
            Nu_wi(i)  = 0.664*Pr_Tfi(i).^(1/3).*Re_w(i).^(1/2);
            elseif Re_w(i)>5e+5 & Re_w(i)<5.5e+6
            Nu_wi(i)  = 0.036*Pr_Tfi(i).^(0.43).*(Re_w(i).^(0.8)-9200);
            else
            disp('Renolds number not in the range ');
            end
    hc_wi(i)        = Nu_wi(i).*k_Tfi(i)/L_w;
    Q_w14(i)        = (Twi(i)-Tin(i))./(1/hc_wi(i));
    DeltaQ_w12(i) = Q_w13(i)-Q_w14(i);
    m(i)            = (Two2(i)-Two1(i))./(DeltaQ_w12(i)-DeltaQ_w11(i));
    c(i)            = Two1(i)-m(i)*DeltaQ_w11(i);
    x(i)            = c(i);
    Two2(i)         = Two1(i);
    Two1(i)         = x(i);
    end
end
mm(i)  = Two1(i);
nn(i)  = Two2(i);
oo(i)  = Twi(i);
Two1(i) = pp(i);
Two2(i) = qq(i);
Twi(i)  = rr(i);
```

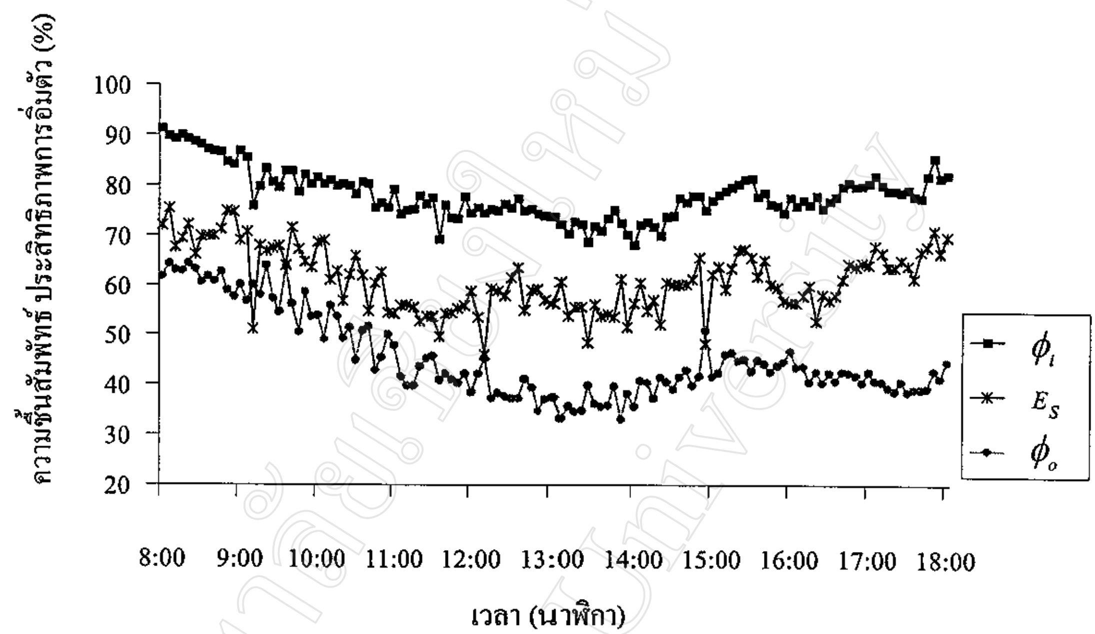
```
while DeltaQ_w21(i)>0.1 | DeltaQ_w21(i)<-0.1
Tfo(i)          = (Tam(i)+Two1(i))/2;
kineviscos_Tfo(i)= (9.48e-002*Tfo(i)-1.255e+001)*0.000001;
k_Tfo(i)        = (7.7e-002*Tfo(i)+3.2e+000)*0.001;
Pr_Tfo(i)       = -2.0e-004*Tfo(i)+7.67e-001;
B_Tfo(i)        = 1/Tfo(i);
Gr_w(i)         = abs(9.81*B_Tfo(i).*(Two1(i)-Tam(i))*(L_w^3))./(kineviscos_Tfo(i).^2);
Ra_w(i)         = Gr_w(i).*Pr_Tfo(i);
Nu_wo(i)        = (0.825+((0.387*Ra_w(i).^(1/6))./(1+(0.492/Pr_Tfo(i)).^(9/16)).^(8/27))).^2;
hc_wo(i)        = Nu_wo(i).*k_Tfo(i)/L_w;
hr(i)           = 5.67e-8*Emissivity_w*(Tsky(i)+Two1(i)).*(Tsky(i).^2+Two1(i).^2);
Q_w21(i)        = hr(i).*(Tsky(i)-Two1(i))+hc_wo(i).*(Tam(i)-Two1(i))+abs(Qabdel_w2(i));
Twi(i)          = Two1(i)-Q_w21(i)*(thick_w/k_w);
Tfi(i)          = (Twi(i)+Tin(i))/2;
kineviscos_Tfi(i)= (9.48e-002*Tfi(i)-1.255e+001)*0.000001;
k_Tfi(i)        = (7.7e-002*Tfi(i)+3.2e+000)*0.001;
Pr_Tfi(i)       = -2.0e-004*Tfi(i)+7.67e-001;
B_Tfi(i)        = 1/Tfi(i);
Re_w(i)         = Vfp*L_w/kineviscos_Tfi(i);
if Re_w(i)<5e+5
Nu_wi(i)     = 0.664*Pr_Tfi(i).^(1/3).*Re_w(i).^(1/2);
elseif Re_w(i)>5e+5 & Re_w(i)<5.5e+6
Nu_wi(i)     = 0.036*Pr_Tfi(i).^(0.43).*(Re_w(i).^(0.8)-9200);
else
disp('Renolds number not in the range ');
end
hc_wi(i)         = Nu_wi(i).*k_Tfi(i)/L_w;
Q_w22(i)         = (Twi(i)-Tin(i))./(1/hc_wi(i));
DeltaQ_w21(i) = Q_w21(i)-Q_w22(i);
    if DeltaQ_w21(i)<-0.1 | DeltaQ_w21(i)>0.1
    Tfo(i)         = (Tam(i)+Two2(i))/2;
    kineviscos_Tfo(i)= (9.48e-002*Tfo(i)-1.255e+001)*0.000001;
```

```
k_Tfo(i)        = (7.7e-002*Tfo(i)+3.2e+000)*0.001;
Pr_Tfo(i)       = -2.0e-004*Tfo(i)+7.67e-001;
B_Tfo(i)        = 1/Tfo(i);
Gr_w(i)         = abs(9.81*B_Tfo(i).*(Two2(i)-Tam(i))*(L_w^3))./(kineviscos_Tfo(i).^2);
Ra_w(i)         = Gr_w(i).*Pr_Tfo(i);
Nu_wo(i)        = (0.825+((0.387*Ra_w(i).^(1/6))./(1+(0.492/Pr_Tfo(i)).^(9/16)).^(8/27))).^2;
hc_wo(i)        = Nu_wo(i).*k_Tfo(i)/L_w;
hr(i)           = 5.67e-8*Emissivity_w*(Tsky(i)+Two2(i)).*(Tsky(i).^2+Two2(i).^2);
Q_w23(i)        = hr(i).*(Tsky(i)-Two2(i))+hc_wo(i).*(Tam(i)-Two2(i))+abs(Qabdel_w2(i));
Twi(i)          = Two2(i)-Q_w23(i)*(thick_w/k_w);
Tfi(i)          = (Twi(i)+Tin(i))/2;
kineviscos_Tfi(i)= (9.48e-002*Tfi(i)-1.255e+001)*0.000001;
k_Tfi(i)        = (7.7e-002*Tfi(i)+3.2e+000)*0.001;
Pr_Tfi(i)       = -2.0e-004*Tfi(i)+7.67e-001;
B_Tfi(i)        = 1/Tfi(i);
Re_w(i)         = Vfp*L_w/kineviscos_Tfi(i);
    if Re_w(i)<5e+5
    Nu_wi(i)    = 0.664*Pr_Tfi(i).^(1/3).*Re_w(i).^(1/2);
    elseif Re_w(i)>5e+5 & Re_w(i)<5.5e+6
    Nu_wi(i)    = 0.036*Pr_Tfi(i).^(0.43).*(Re_w(i).^(0.8)-9200);
    else
    disp('Renolds number not in the range ');
    end
hc_wi(i)        = Nu_wi(i).*k_Tfi(i)/L_w;
Q_w24(i)        = (Twi(i)-Tin(i))./(1/hc_wi(i));
DeltaQ_w22(i)   = Q_w23(i)-Q_w24(i);
m(i)            = (Two2(i)-Two1(i))./(DeltaQ_w22(i)-DeltaQ_w21(i));
c(i)            = Two1(i)-m(i)*DeltaQ_w21(i);
x(i)            = c(i);
Two2(i)         = Two1(i);
Two1(i) = x(i);
end
```

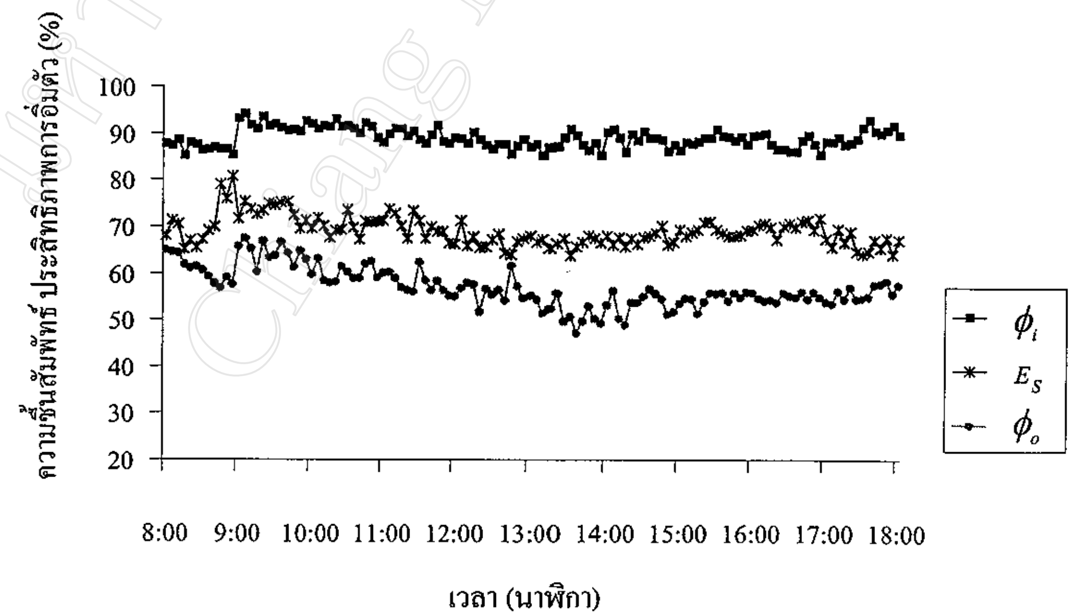
```
  end
  pp(i)       = Two1(i);
  qq(i)       = Two2(i);
  rr(i)       = Twi(i);
  Qvent(i)    = m_rate(i).*Cp(i).*(Tinlet(i)-Tin(i));
  Qtotal(i)   = Q_r11(i)*A_r1+Q_r21(i)*A_r2+Q_w11(i)*A_w1+Q_w21(i)*A_w2+Qvent(i)+Qswine;
  Tin(i)      = Qtotal(i)./(m_rate(i).*Cp(i))+Tin(i);
end
```

ภาคผนวก ง

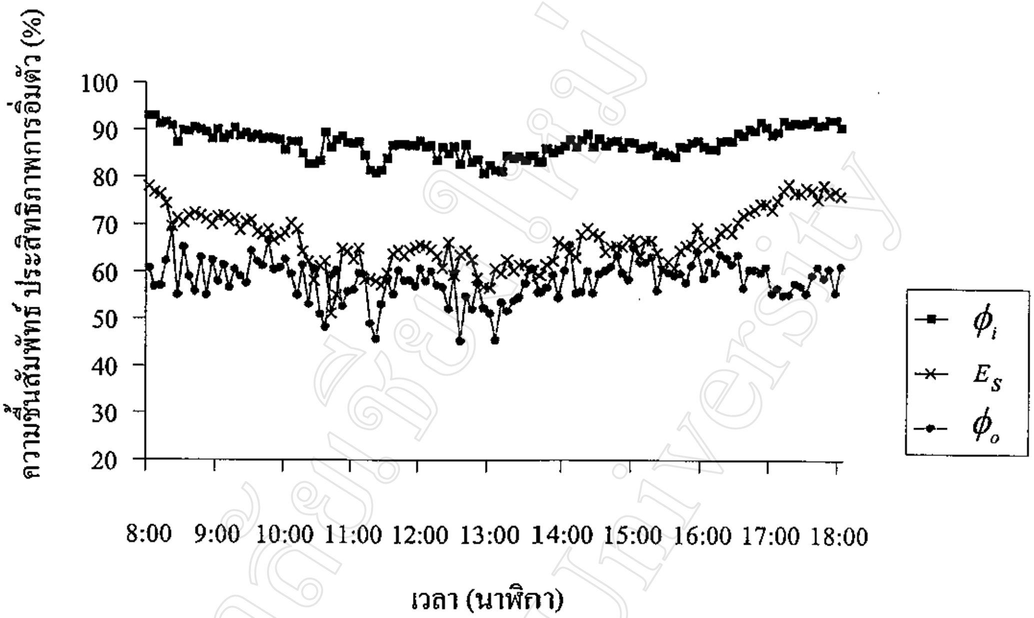
แผนภูมิความชื้นสัมพัทธ์ของอากาศก่อนและหลังผ่านแผงระเหยน้ำ
แผนภูมิประสิทธิภาพการอิ่มตัว ที่ 0.50 m^3/s, 0.75 m^3/s และวิธีหาความชื้นสัมพัทธ์ของอากาศ



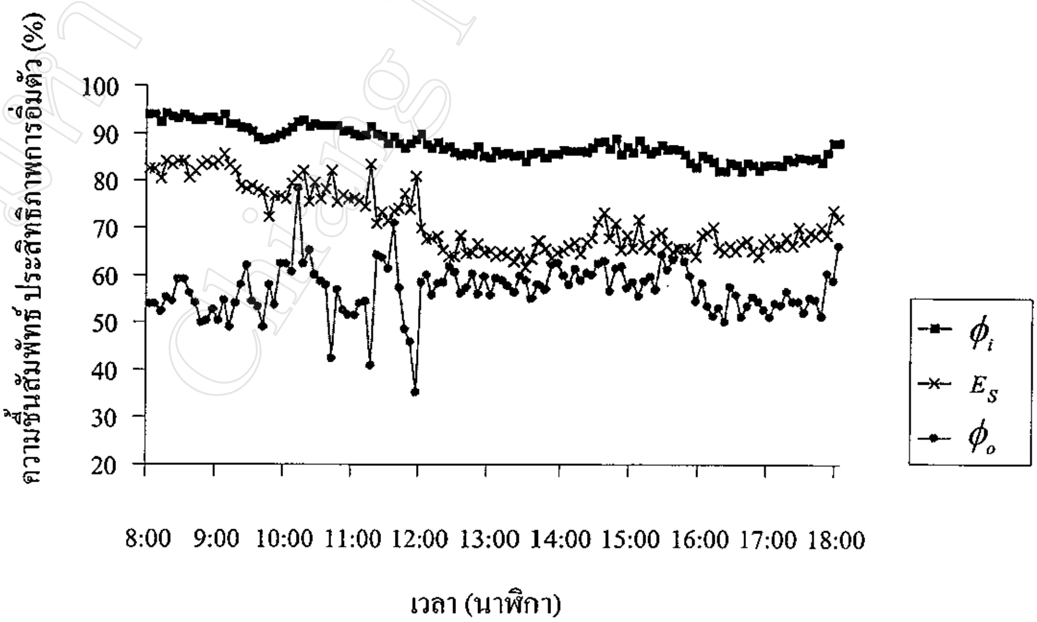
รูป ง.1 ความชื้นสัมพัทธ์ของอากาศก่อนและหลังผ่านแผงระเหยน้ำแบบกระสอบป่าน และประสิทธิภาพการอิ่มตัว ที่ 0.50 m^3/s



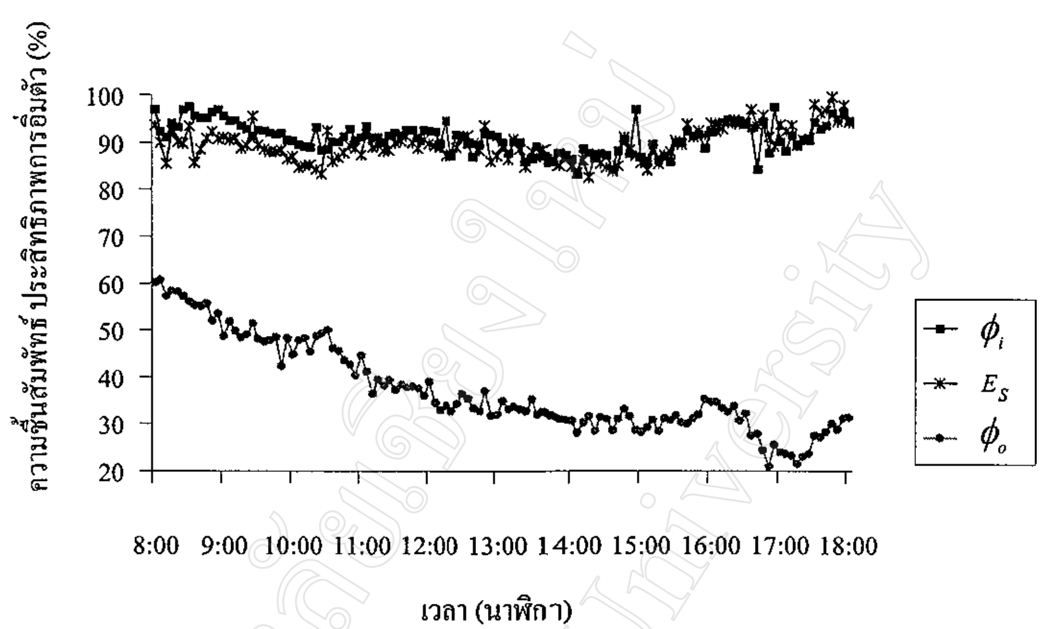
รูป ง.2 ความชื้นสัมพัทธ์ของอากาศก่อนและหลังผ่านแผงระเหยน้ำแบบกระสอบป่าน และประสิทธิภาพการอิ่มตัว ที่ 0.75 m^3/s



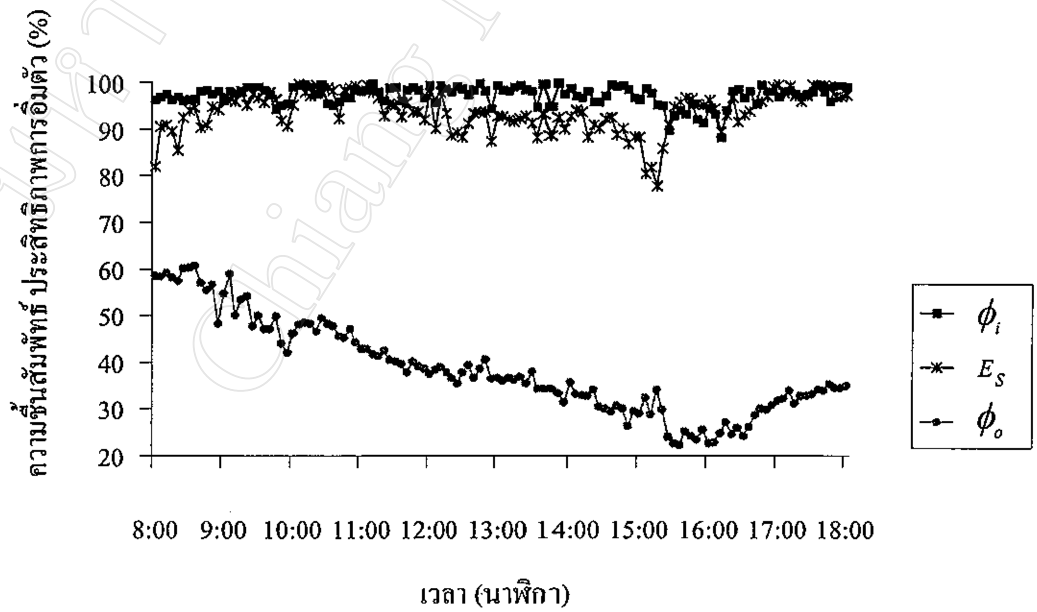
รูป ง.3 ความชื้นสัมพัทธ์ของอากาศก่อนและหลังผ่านแผงระเหยน้ำแบบคอนกรีตมีรูพรุน และประสิทธิภาพการอิ่มตัว ที่ 0.50 m^3/s



รูป ง.4 ความชื้นสัมพัทธ์ของอากาศก่อนและหลังผ่านแผงระเหยน้ำแบบคอนกรีตมีรูพรุน และประสิทธิภาพการอิ่มตัว ที่ 0.75 m^3/s



รูป ง.5 ความชื้นสัมพัทธ์ของอากาศก่อนและหลังผ่านแผงระเหยน้ำแบบเยื่อกระดาษ และประสิทธิภาพการอิ่มตัว ที่ 0.50 m^3/s



รูป ง.6 ความชื้นสัมพัทธ์ของอากาศก่อนและหลังผ่านแผงระเหยน้ำแบบเยื่อกระดาษ และประสิทธิภาพการอิ่มตัว ที่ 0.75 m^3/s

การหาความชื้นสัมพัทธ์ของอากาศ เมื่อทราบอุณหภูมิแห้ง (T_d) และอุณหภูมิกระเปาะเปียก (T_w) (ASHRAE, 1985) มีขั้นตอนดังต่อไปนี้

1. คำนวณความดันไอน้ำอิ่มตัว (Saturation pressure of water vapor, P_{vs}) ที่อุณหภูมิ T_d (K) และ T_w (K)

$$\ln(P_{vs,T_d}) = C_1/T_d + C_2 + C_3(T_d) + C_4(T_d)^2 + C_5(T_d)^3 + C_6(\ln T_d) \qquad (ง.1)$$

$$\ln(P_{vs,T_w}) = C_1/T_w + C_2 + C_3(T_w) + C_4(T_w)^2 + C_5(T_w)^3 + C_6(\ln T_w) \qquad (ง.2)$$

เมื่อ

$C_1 = -5800.2206$

$C_2 = 1.3914993$

$C_3 = -0.04860239$

$C_4 = 0.41764768 \times 10^{-4}$

$C_5 = -0.14452093 \times 10^{-7}$

$C_6 = 6.5459673$

2. คำนวณอัตราส่วนความชื้นของอากาศอิ่มตัว (ω_s) ที่อุณหภูมิ T_w (K)

$$\omega_{s,T_w} = 0.62198\left(\frac{P_{vs,T_w}}{P - P_{vs,T_w}}\right) \qquad (ง.3)$$

เมื่อ P คือ ความดันบรรยากาศ เท่ากับ 101325 Pa (ที่ระดับน้ำทะเล อุณหภูมิอากาศ 15°C)

3. คำนวณอัตราส่วนความชื้น (ω)

$$\omega = \frac{(2501 - 2.381T_w)\omega_{s,T_w} - (T_d - T_w)}{2501 + 1.805T_d - 4.186T_w} \qquad (ง.4)$$

4. คำนวณความดันบางส่วนของไอน้ำ (P_v)

$$P_v = \frac{P\omega}{0.62189 + \omega} \qquad (ง.5)$$

5. คำนวณความชื้นสัมพัทธ์ (ϕ,%)

$$\phi = \frac{P_v}{P_{vs,T_d}} \times 100 \qquad (ง.6)$$

ภาคผนวก จ

สมการทำนายอุณหภูมิอากาศภายในโรงเรือนทดลอง

สมการทำนายอุณหภูมิอากาศในโรงเรือนทดลอง

จากข้อมูลการทดลองทำการหาสมการทำนายอุณหภูมิอากาศภายในโรงเรือนทดลอง ตามประเภทของแผงระเหยน้ำ แล้วหา T_{di} โดยเลือก T_{do} และ T_{wo} จากการทดลอง 1 วัน คือ วันที่ 9 พฤษภาคม พ.ศ. 2545 ได้ผลดังตาราง จ.1-จ.3

จ.1 สมการทำนายอุณหภูมิอากาศในโรงเรือนทดลองที่ใช้แผงระเหยน้ำแบบกระสอบป่าน

F (m^3/s)	สมการ	R^2	$T_{do}-T_{di}$ เฉลี่ย	$T_{do}-T_{di}$ สูงสุด
0.25	$T_{di}=0.02676T_{do}^2-0.0361(T_{do}-T_{wo})^2-0.599T_{do}-0.0216(T_{do}-T_{wo})+21.145$	0.918	6.2	9.0
0.50	$T_{di}=-0.0258T_{do}^2+0.03747(T_{do}-T_{wo})^2+2.775T_{do}-1.393(T_{do}-T_{wo})-27.044$	0.962	6.7	9.5
0.75	$T_{di}=0.04823T_{do}^2-0.061(T_{do}-T_{wo})^2-2.541T_{do}+0.868(T_{do}-T_{wo})+55.159$	0.966	7.1	10.3
1.00	$T_{di}=0.009218T_{do}^2-0.00806(T_{do}-T_{wo})^2+0.263T_{do}-0.26(T_{do}-T_{wo})+11.742$	0.956	6.2	8.7

ตาราง จ.2 สมการทำนายอุณหภูมิอากาศในโรงเรือนทดลองที่ใช้แผงระเหยน้ำแบบคอนกรีตมีรูพรุน

F (m^3/s)	สมการ	R^2	$T_{do}-T_{di}$ เฉลี่ย	$T_{do}-T_{di}$ สูงสุด
0.25	$T_{di}=-0.0611T_{do}^2+0.09095(T_{do}-T_{wo})^2+4.654T_{do}-1.297(T_{do}-T_{wo})-52.677$	0.911	2.9	4.1
0.50	$T_{di}=0.00001T_{do}^2+0.01362(T_{do}-T_{wo})^2+0.876T_{do}-0.495(T_{do}-T_{wo})+2.831$	0.966	5.0	9.2
0.75	$T_{di}=-0.00001T_{do}^2+0.008618(T_{do}-T_{wo})^2+0.98T_{do}-0.65(T_{do}-T_{wo})+0.735$	0.952	5.6	7.9
1.00	$T_{di}=0.01475T_{do}^2+0.009873(T_{do}-T_{wo})^2+0.182T_{do}-0.715(T_{do}-T_{wo})+11.726$	0.970	5.1	6.3

ตาราง จ.3 สมการทำนายอุณหภูมิอากาศในโรงเรือนทดลองที่ใช้แผงระเหยน้ำแบบเยื่อกระดาษ

F (m³/s)	สมการ	R^2	$T_{do}-T_{di}$ เฉลี่ย	$T_{do}-T_{di}$ สูงสุด
0.25	$T_{di}=-0.0414T_{do}^2+0.12(T_{do}-T_{wo})^2+3.329T_{do}-2.122(T_{do}-T_{wo})-29.198$	0.805	6.9	8.3
0.50	$T_{di}=0.02647T_{do}^2-0.0254(T_{do}-T_{wo})^2-0.635T_{do}-0.5(T_{do}-T_{wo})+23.69$	0.763	8.9	13.1
0.75	$T_{di}=0.04789T_{do}^2-0.0659(T_{do}-T_{wo})^2-2.568T_{do}+0.933(T_{do}-T_{wo})+53.361$	0.647	10.1	13.8
1.00	$T_{di}=-0.039T_{do}^2+0.03451(T_{do}-T_{wo})^2+3.276T_{do}-1.363(T_{do}-T_{wo})-32.061$	0.648	10.2	15.2

ภาคผนวก ฉ

การคำนวณน้ำหนักสุกรจากอุณหภูมิอากาศ

การคำนวณน้ำหนักสุกรจากอุณหภูมิอากาศภายในโรงเรือน และคำนวณรายได้จากการขายสุกร

น้ำหนักสุกรที่อาศัยในโรงเรือนจะขึ้นกับอุณหภูมิอากาศภายในโรงเรือน โดยอุณหภูมิอากาศที่ค่อนข้างต่ำจะลดความเครียดที่เกิดจากความร้อน ทำให้สุกรกินอาหารได้มากขึ้น จึงได้มีการนำระบบทำความเย็นแบบระเหยโดยตรงมาใช้เพื่อลดอุณหภูมิอากาศในโรงเรือน

หัวข้อนี้จะเป็นการคำนวณหาน้ำหนักสุกรในกรณีที่เป็นโรงเรือนแบบเปิดซึ่งไม่ใช้ระบบทำความเย็นแบบระเหยโดยตรง และแบบใช้ระบบทำความเย็นแบบระเหยโดยตรงที่แผงระเหยน้ำขนาด 14 ตารางเมตร และ 21 ตารางเมตร ซึ่งใช้ข้อมูลน้ำหนักของสุกรที่เพิ่มขึ้นต่อวันจากผลของอุณหภูมิ ดังตาราง ฉ.1 โดยยกตัวอย่างการคำนวณในวันแรกของแต่ละฤดู ในช่วงเวลาต่างๆ มาแสดง ดังตาราง ฉ.2 ซึ่งผลของน้ำหนักในวันต่างๆ จะมีผลในการคำนวณในวันถัดไปจนครบ 120 วัน การคำนวณจะกำหนดให้อุณหภูมิอากาศภายในโรงเรือนช่วงเวลาที่ไม่ได้ใช้ระบบทำความเย็นมีค่าเท่ากัน คือ ตั้งแต่เวลา 19.00-7.00น. โดยอุณหภูมิอากาศภายในโรงเรือนแบบเปิดกำหนดให้ต่ำกว่าอุณหภูมิอากาศภายนอก 0.1-3.8 องศาเซลเซียส

จากการคำนวณน้ำหนักสุกรจนครบ 120 วัน ด้วยโปรแกรมคอมพิวเตอร์ ได้ผลของน้ำหนักสุกรดังตาราง ฉ.3

จากน้ำหนักสุกรที่เพิ่มขึ้นต่อตัวในตาราง ฉ.3 นำไปคูณกับราคาขายสุกร (กิโลกรัมละ 70 บาท) จะได้รายได้ที่เพิ่มขึ้นต่อตัว และนำรายได้ที่เพิ่มขึ้นต่อตัวคูณกับจำนวนสุกรในโรงเรือน (600 ตัว) เป็นรายได้ที่เพิ่มขึ้นจากการใช้ระบบทำความเย็นแบบระเหยโดยตรง ดังตาราง ฉ.4

จากตาราง ฉ.4 แสดงให้เห็นว่าโรงเรือนเลี้ยงสุกรที่ใช้ระบบทำความเย็นแบบระเหยโดยตรงที่ใช้แผงระเหยน้ำขนาด 14 และ 21 ตารางเมตร มีรายได้เพิ่มขึ้นต่อปีเมื่อเปรียบเทียบกับโรงเรือนแบบเปิด เท่ากับ 348,600 และ 772,800 บาท ตามลำดับ

ตาราง ฉ.1 ผลของอุณหภูมิต่อการเติบโตต่อวันของสุกร (ก.ก.)

น้ำหนัก (ก.ก.)	อุณหภูมิ (°C)							
	4	10	16	21	27	32	28	43
45	-	0.62	0.72	0.91	0.89	0.64	0.18	0.60
68	0.58	0.67	0.79	0.98	0.83	0.52	0.19	1.18
90	0.54	0.71	0.87	1.01	0.76	0.40	0.35	-
113	0.50	0.76	0.84	0.97	0.68	0.28	0.62	-
136	0.46	0.80	1.02	0.93	0.62	0.16	0.88	-
159	0.43	0.85	1.09	0.90	0.55	0.15	0.15	-

ที่มา: บุญลือ (2536)

ตาราง ฉ.2 อุณหภูมิอากาศในโรงเรือนและน้ำหนักสุกรของวันแรกในการคำนวณ

ฤดู	เวลา (นาฬิกา)	$T_{di\,SH}$ (°C)			น.น. สุกรที่เพิ่มขึ้น (ก.ก.)			น.น. สุกร (ก.ก.)		
		No evap.	14 m^2	21 m^2	No evap.	14 m^2	21 m^2	No evap.	14 m^2	21 m^2
ร้อน	1-4	24.13	24.13	24.13	0.1124	0.1124	0.1124	45.112	45.112	45.112
	4-7	22.93	22.80	22.80	0.1130	0.1130	0.1130	45.225	45.225	45.225
	7-10	25.00	24.09	23.11	0.1121	0.1125	0.1129	45.338	45.338	45.338
	10-13	29.75	28.24	25.95	0.0939	0.1036	0.1116	45.431	45.442	45.450
	13-16	31.20	29.61	26.77	0.0847	0.0948	0.1112	45.516	45.536	45.561
	16-19	29.08	27.57	25.16	0.0979	0.1076	0.1120	45.614	45.644	45.673
	19-22	27.63	26.97	26.11	0.1070	0.1111	0.1115	45.721	45.755	45.785
	22-1	26.73	26.73	26.73	0.1111	0.1111	0.1111	45.832	45.866	45.896
ฝน	1-4	23.53	23.53	23.53	0.1127	0.1127	0.1127	45.113	45.113	45.113
	4-7	23.18	23.15	23.15	0.1128	0.1129	0.1129	45.226	45.226	45.226
	7-10	23.80	23.67	23.64	0.1126	0.1127	0.1127	45.338	45.338	45.338
	10-13	25.33	24.92	24.51	0.1119	0.1121	0.1123	45.450	45.450	45.451
	13-16	26.18	25.52	24.88	0.1115	0.1118	0.1121	45.562	45.562	45.563
	16-19	25.23	24.78	24.40	0.1119	0.1121	0.1123	45.673	45.674	45.675
	19-22	24.35	24.25	24.15	0.1123	0.1124	0.1124	45.786	45.787	45.787
	22-1	24.25	24.25	24.25	0.1124	0.1124	0.1124	45.898	45.899	45.900
หนาว	1-4	18.88	18.88	18.88	0.1038	0.1038	0.1038	45.104	45.104	45.104
	4-7	17.88	17.83	17.83	0.0991	0.0988	0.0988	45.203	45.203	45.203
	7-10	19.95	19.52	19.23	0.1088	0.1067	0.1055	45.109	45.107	45.106
	10-13	24.10	23.15	21.86	0.1125	0.1129	0.1135	45.221	45.220	45.219
	13-16	26.28	24.96	22.81	0.1114	0.112	0.113	45.111	45.112	45.113
	16-19	24.43	23.38	21.98	0.1123	0.1128	0.1135	45.224	45.225	45.227
	19-22	21.45	21.15	20.90	0.1138	0.1139	0.1135	45.114	45.114	45.114
	22-1	19.85	19.85	19.85	0.1086	0.1086	0.1086	45.222	45.223	45.222

ตาราง ฉ.3 น้ำหนักและราคาสุกรจากการใช้ระบบทำความเย็นแบบระเหยโดยตรงในเวลา 120 วัน

ฤดู	น.น. สุกร/ตัว (ก.ก.)			น้ำหนักสุกรที่เพิ่มขึ้น/ตัว (ก.ก.)	
	No evap.	14 m^2	21 m^2	14 m^2 -No evap.	21 m^2 - No evap.
ร้อน	130.3	135.7	142.3	5.4	12.0
ฝน	144.8	145.8	146.6	1.0	1.8
หนาว	151.3	153.2	156.0	1.9	4.6

ตาราง ฉ.4 รายได้จากการขายสุกรที่เพิ่มขึ้นเมื่อใช้ระบบทำความเย็นแบบระเหยโดยตรง

ฤดู	รายได้ที่เพิ่มขึ้น/ตัว (บาท)		รายได้ที่เพิ่มขึ้น/600ตัว (บาท)	
	14 m^2 -No evap.	21 m^2 - No evap.	14 m^2 -No evap.	21 m^2 - No evap.
ร้อน	378	840	226,800	504,000
ฝน	70	126	42,000	75,600
หนาว	133	322	79,800	193,200
รวม/ปี	581	1288	348,600	772,800

ประวัติผู้เขียน

ชื่อ นายกลศ บุณยะวรรธนะ

วัน เดือน ปี เกิด 8 พฤศจิกายน พ.ศ. 2519

สถานที่เกิด จังหวัดนครสวรรค์

วุฒิการศึกษา ปริญญาตรี วิศวกรรมศาสตรบัณฑิต (เครื่องกล) จากมหาวิทยาลัยเชียงใหม่ ปีการศึกษา 2541