Problem set 4 (PS4) Due Monday February 13

PS4-1

Using EES redo the example problem from the notes, reproduced below, with an energy recovery heat exchanger having a thermal effectiveness of 80% located between the outside air flow and the exhaust air flow and determine the reduction in coil load.

Outside air at 90 F db and 75 F wb is mixed with return air in a mass proportion of 1/3 outside air to 2/3 return air and cooled in a coil to supply conditions. Return conditions are 75 F, 50% relative humidity. The space cooling load is 100,000 but/hr and the space sensible heat factor is .8. Supply temperature is 55 F. Determine the coil load in Btu/hr.

PS4-1

A building has a total heating load of 200,000 Btu/hr. The sensible heat factor for the space is .8 and the space is to be maintained at 72 F db and 30% relative humidity. Outside air at 40 F db and 20% relative humidity in the amount of 1000 cfm is required. Air is supplied to the space at 120 F db. Outside air is mixed with return air, heated in a furnace, and humidified to provide the supply flow. Water vapor with an enthalpy of 1150 Btu/lb is used to humidify the air. Determine the condition and amount of the supply air, the temperature rise of the air through the furnace, the amount of water vapor required for humidification and the capacity of the furnace. Atmospheric pressure is 14.7 psia. Calculate results or use EES.

PS4-3

Conditions in one zone of a dual-duct conditioning system are to be maintained at 24 C and 50% relative humidity. The cold deck air at 11 C and 90% relative humidity and the hot deck air is outdoor air at 32 C and 20% relative humidity. The sensible heat factor for the zone is .65. Using a psychrometric chart determine in what proportion must the warm and cold air be mixed to satisfy the space condition. If the total zone load is 176 KW what is the total volume flow rate of air supplied to the zone? Atmospheric pressure is 101.325 kPa.

"PS4-1 2012"

"INPUT"
To=90
Twbo=75
TR=75
RR=.5
Ts=55
SHFspace=.8
MRo=.333
Qspace=100000.
pamb=14.7

"SOLUTION"
wo=humrat(AirH2O,T=To,B=Twbo,p=pamb)
wo1=wo
To1=To-.8*(To-TR)
ho1=enthalpy(AirH2O,T=To1,w=wo1,p=pamb)

hR=enthalpy(AirH2O,T=TR,R=RR,p=pamb)
wR=humrat(AirH2O,T=TR,R=RR,p=pamb)
hRv=enthalpy(steam, T=TR,x=1)
hRl=enthalpy(steam, T=TR,x=0)

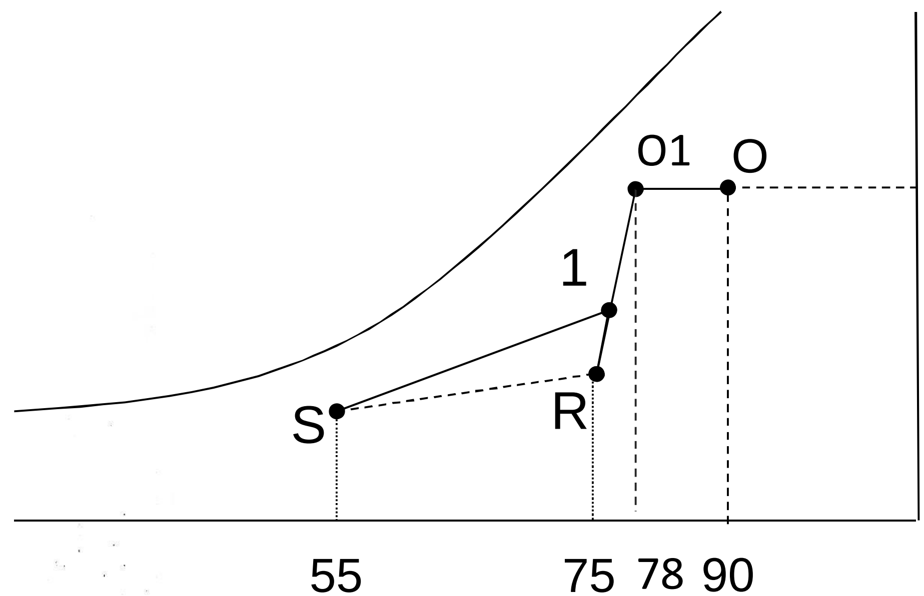
h1=(MRo)*ho1+(1-mRo)*hR
w1=(MRo)*wo1+(1-mRo)*wR
T1=Temperature(AirH2O,h=h1,w=w1,p=pamb)
h1v=enthalpy(steam, T=T1,x=1)
h1l=enthalpy(steam, T=T1,x=0)

Qspace*SHFspace=ms*(TR-Ts)*(.24+ws*.45+(wR-ws))
Qspace*(1-SHFspace)=ms*(wR-ws)*(hRv-hRl)

hs=enthalpy(AirH2O,T=Ts,w=ws,p=pamb)

Qcoil=ms*(h1-hs)

PS4-1



SOLUTION

Unit Settings: Eng F psia mass deg

h1 = 30.56	h1l = 44.04	h1v = 1094	ho1 = 35.42	hR = 28.13
hRl = 43.04	hRv = 1094	hs = 21.97	MRo = 0.333	ms = 16340
pamb = 14.7	Qcoil = 140243	Qspace = 100000	RR = 0.5	SHFspace = 0.8
T1 = 76.01	To = 90	To1 = 78	TR = 75	Ts = 55
Twbo = 75	w1 = 0.01123	wo = 0.01522	wo1 = 0.01522	wR = 0.009234
ws = 0.008069				

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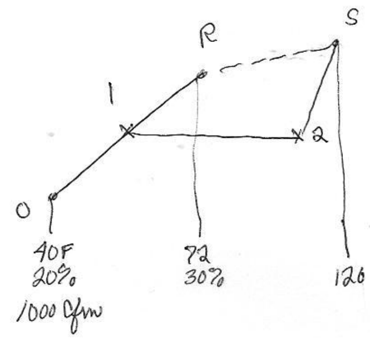
PS4-2

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"Spitler 3-36 ed 6 EES"
"INPUT PARAMETERS"
pamb=14.7
Qspace=200000.
To=40
TR=72
Ts=120
RR=.3
Ro=.2
hw=1050     "Saturated steam at 14.7 psia"
SHFspace=.8
Volo=1000

"Point O, outside"
ho=enthalpy(AirH2O,p=pamb,T=To,R=Ro)
wo=humrat(AirH2O,p=pamb,T=To,R=Ro)
vo=volume(AirH2O,p=pamb,T=To,R=Ro)

"Point R, return"
hR=enthalpy(AirH2O,p=pamb,T=TR,R=RR)
wR=humrat(AirH2O,p=pamb,T=TR,R=RR)
vR=volume(AirH2O,p=pamb,T=TR,R=RR)

"Mass and energy balances to get state point properties"
"9 equations 9 unknowns"

Qspace*SHFspace=ms*.24*(Ts-TR) +ms*wR*.45*(Ts-TR) +ms*(wR-ws)*(TR-Ts)          "Space sensible energy
 balance"
hsv=enthalpy(STEAM,T=Ts,x=1)
hsl=enthalpy(STEAM,T=Ts,x=0)
Qspace*(1-SHFspace)=ms*(ws-wR)*(hsv-hsl)   "Space latent energy balance"
mo=Volo*60/vo
h1=(mo/ms)*ho+(1-(mo/ms))*hR                 "Mixing  energy balance"
w1=(mo/ms)*wo+(1-(mo/ms))*wR                 "Mixing water mass balance"
hs=enthalpy(AirH2O,p=pamb,T=Ts,W=ws)
w1=w2
hw=(hs-h2)/(ws-w2)
T1=temperature(AirH2O,p=pamb,h=h1,W=w1)
T2=temperature(AirH2O,p=pamb,h=h2,W=w2)
FurnacedT=T2-T1
"Results mass and energy balances"
mwater=ms*(ws-w2)
Qfurnace=ms*(h2-h1)
vs=volume(AirH2O,p=pamb,T=Ts,W=Ws)
VolSupply=ms*vs/60
```

SOLUTION

Unit Settings: [F]/[psia]/[lbm]/[degrees]

FurnacedT = 60.27	h1 = 18.54	h2 = 33.13	ho = 10.72
hR = 22.74	hs = 37.59	hsl = 88	hsv = 1113
hw = 1050	mo = 4757	ms = 13599	mwater = 57.77
pamb = 14.7	Qfurnace = 198398	Qspace = 200000	Ro = 0.2

PS4-3 2012

```
"PS4-3 2012"

"INPUT"
TR=24
RR=.50
Thot=32
Rhot=.20
Tcold=11
Rcold=.90
Ts=14.2
patm=101.325
ws=.007

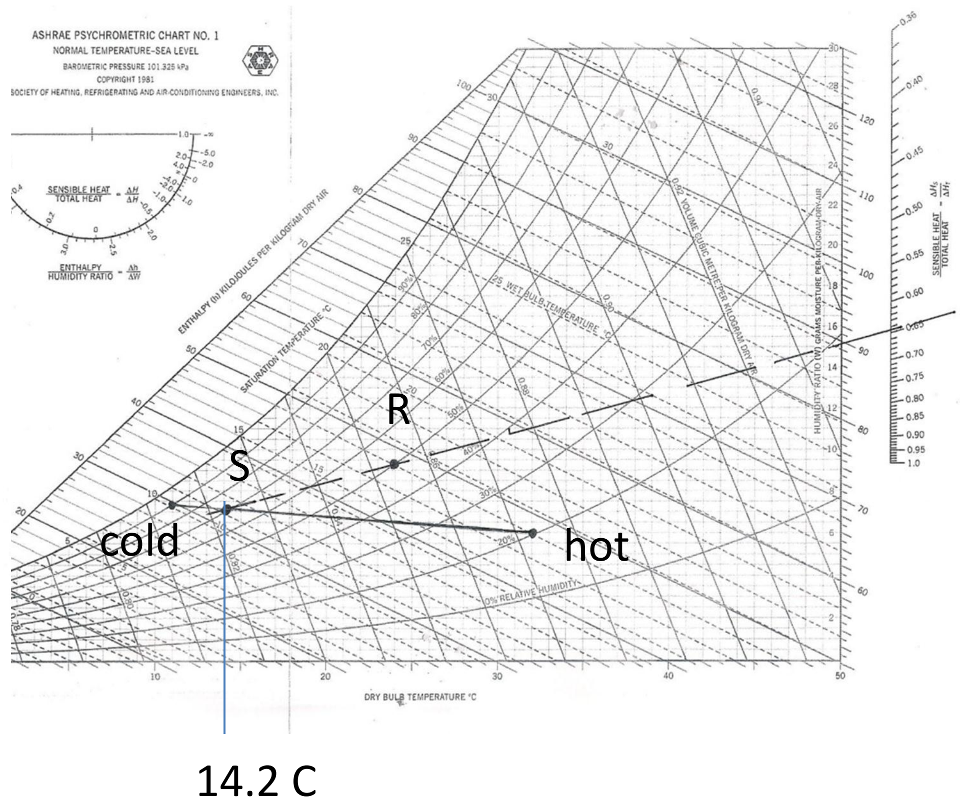
"SOLUTION"
hR=enthalpy(AirH2O,T=TR,R=RR,p=patm)
hhot=enthalpy(AirH2O,T=Thot,R=Rhot,p=patm)
hcold=enthalpy(AirH2O,T=Tcold,R=Rcold,p=patm)
hs=enthalpy(AirH2O,T=Ts,w=ws,p=patm)
vs=volume(AirH2O,T=Ts,w=ws,p=patm)

50*200/.9478=ms*(hR-hs)                    "Spoace Energy Balance"
hs=(mhot/ms)*hhot+(1-(mhot/ms))*hcold      "Mixing Energy Balance"
VolSupply=ms*vs
HotColdRatio=mhot/(ms-mhot)
```

SOLUTION

Unit Settings: SI C kPa kJ mass deg

hcold = 29.57	hhot = 47.31	HotColdRatio = 0.1573	hR = 47.83
hs = 31.98	mhot = 90.49	ms = 665.9	patm = 101.3
Rcold = 0.9	Rhot = 0.2	RR = 0.5	Tcold = 11
Thot = 32	TR = 24	Ts = 14.2	VolSupply = 548.1
vs = 0.8232	ws = 0.007		



$$\text{Supply Volume} = 548.1\,\text{m}^3/\text{min}$$

$$\text{Hot to Cold ratio} = .1573$$