ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF PUMPED SOLAR HOT WATER SYSTEMS

BY

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THESIS

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ABSTRACT

A transient computer model of a forced circulation solar hot water system has been developed. The model allows for capacitance effects by solving the energy balances on a four node model of the solar collector. The tank model is designed to include the presence of an auxiliary heater and to allow for the nonideal condition of load drawoff.

Five tests were done to validate the computer model. These tests include a comparison of the computer simulation with experimental data and a model available in the literature. The results of these tests indicate that the computer model is able to predict the collector inlet and outlet temperatures within 10% for typical operating conditions.

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REAL TIME (HRS)	LOAD FLOW (GAL)	MASS FLOW (GPH)	COLLECTOR INLET (°F)	COLLECTOR OUTLET (°F)	TEMP. RISE (°F)	TANK 1 (°F)	TANK 2 (°F)	TANK 3 (°F)	TANK 4 (°F)	MEAN TANK (°F)	INSOLATION (BTU)	USEFUL GAIN (BTU)	COLLECTOR EFFICIENCY (%)
200.	0.0	58.8	114.6	128.4	13.6	123.2	124.0	120.0	115.7	120.7	1446.7	831.0	57.4
208.	0.0	58.8	115.7	125.4	11.7	123.2	124.7	120.9	116.7	121.4	1036.0	716.7	69.2
215.	0.0	58.8	116.7	128.4	10.7	123.2	125.1	121.7	117.7	121.9	1228.4	652.3	53.1
223.	0.2	58.8	117.7	130.0	12.0	123.2	125.9	122.7	118.6	122.6	1324.6	729.7	55.1
230.	0.2	58.8	118.6	132.6	13.1	123.2	127.1	123.3	119.3	123.2	1502.2	801.4	53.3
238.	0.0	58.8	119.3	131.8	13.3	123.2	128.2	124.3	120.1	124.0	1350.5	810.0	60.0
245.	0.0	58.8	120.1	133.9	13.1	123.1	129.2	125.2	121.2	124.7	1461.5	801.6	54.8
253.	0.1	58.8	121.2	134.7	13.6	123.1	130.3	126.3	122.1	125.5	1457.8	831.6	57.0
300.	0.2	58.8	122.1	133.7	12.5	123.2	131.2	127.2	122.9	126.1	1254.3	765.5	61.0
308.	0.0	58.8	122.9	136.2	12.4	123.2	131.9	128.1	123.8	126.7	1417.1	758.7	53.5
315.	0.0	58.8	123.8	135.3	12.4	123.2	132.8	129.1	124.8	127.5	1254.3	757.2	60.4
323.	0.0	58.8	124.8	135.8	11.2	123.1	133.4	129.8	125.9	128.1	1198.8	684.8	57.1
330.	0.1	58.8	125.9	135.8	10.4	123.1	133.8	130.7	126.8	128.6	1117.4	636.0	56.9
338.	0.1	58.8	126.8	139.0	11.1	123.2	134.6	131.4	127.5	129.2	1365.3	675.1	49.4
345.	0.1	58.8	127.5	137.2	10.9	123.2	135.4	132.3	128.3	129.8	1117.4	668.5	59.6
353.	0.1	58.8	128.3	138.1	9.7	123.2	135.9	132.8	129.1	130.2	1117.4	593.7	53.1
400.	0.2	58.8	129.1	138.6	9.7	123.3	136.3	133.6	129.8	130.7	1106.3	588.8	53.2

```
$JOB
      REAL K,MF
      DIMENSION RAD(90),TAMB(90),TINL(90)
      DATA PI/3.14159/
      READ, LL
      READ,WT,D,K,DEL,HF,SIG,EP,EG,DEP,PER,A,TAUA
      IFLAG=0
      MF=488.
      WS=2.
      WRITE(6,91)
   91 FORMAT('1'////)
      READ,(RAD(I),I=1,LL)
      READ,(TAMB(I),I=1,LL)
      READ,(TINL(I),I=1,LL)
      DO 100 L=1,LL
      S=RAD(L)*8.
      TA=TAMB(L)+460.
      TIN=TINL(L)+460.
      SS=S
      S=S*TAUA
      IF(IFLAG.EQ.0) TM=TA+30.
      IF(IFLAG.EQ.0) TG=TA+15.
    5 HRPG=(SIG*(TM*TM+TG*TG)*(TM+TG))/(1./EP+1./EG-1.)
      HCPG=.21*(TM-TG)**.25
      HRGA=SIG*EG*(TG*TG+TA*TA)*(TG+TA)
      HW=1.+.3*WS
      TGC=(TM*(HRPG+HCPG)+TA*(HRGA+HW))/(HRGA+HW+HCPG+HRPG)
      ERR=ABS(TGC-TG)
      IF(ERR.LT.1.) GO TO 10
      TG=TG+.5*(TGC-TG)
      GO TO 5
   10 TG=TGC
      QTOP=HRGA*(TG-TA)+HW*(TG-TA)
      QBOT=.1*QTOP
      QEDGE=.08*DEP*PER*(TM-TA)/A
      QTOT=QTOP+QBOT+QEDGE
      UL=QTOT/(TM-TA)
      PART=((UL/(K*DEL))**.5*(WT-D)/2.)
      F=TANH(PART)/PART
      FPP=F*(WT-D)/WT + D/WT
      FP=FPP/(1.+FPP*UL*WT/(HF*PI*D))
      FR=(MF/(A*UL))*(1.-EXP(-FP*UL*A/MF))
      QU=FR*(S-UL*(TIN-TA))*A
      TMC=TIN+(QU/(A*UL))*(1./FR-1./FP)
      ERR1=ABS(TMC-TM)
      IF (ERR1 .LE. 1.) GO TO 30
      TM=TM+.2*(TMC-TM)
      GO TO 5
   30 TOUT=QU/MF+TIN
      TM=TMC
      SS=SS*A
      EFF=(QU/SS)*100.
      TA=TA-460.
      TMC=TMC-460.
      TGC=TGC-460.
      TIN=TIN-460.
      TOUT=TOUT-460.
      TRISE=TOUT-TIN
      QU=QU/8.
      SS=SS/8.
      WRITE(6,90) MF,TMC,TGC,UL,FP,FR,TA,TIN,TOUT,TRISE,SS,QU,EFF
   90 FORMAT('-',F10.1,2F9.1,3F9.2,7F9.1)
      IFLAG=1
  100 CONTINUE
      STOP
      END

$ENTRY
```