Modelización de procesos termodinámicos mediante el programa Cyclepad

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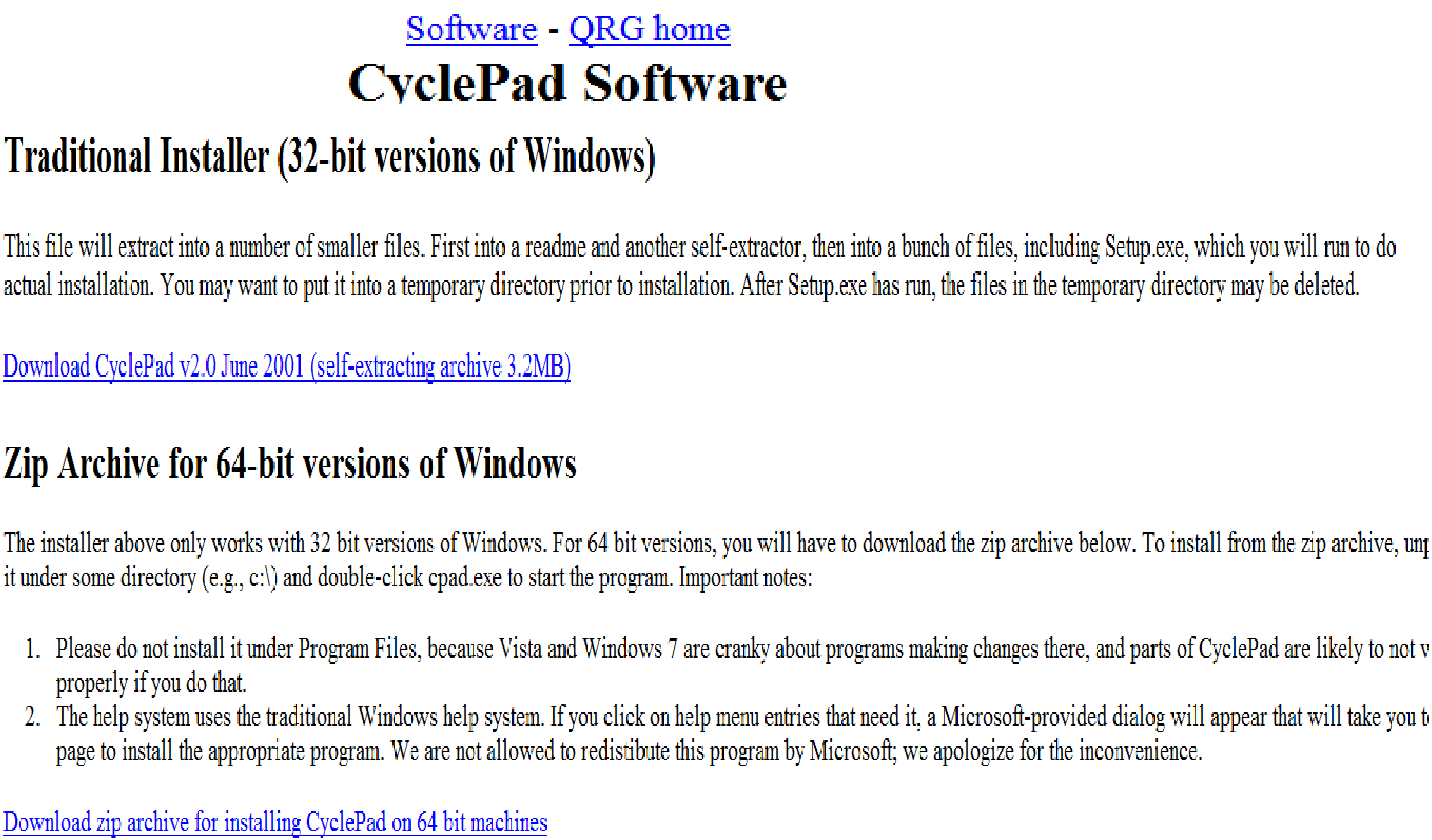
UPCT

Dirección página web

http://www.qrg.northwestern.edu/software/cyclepad/cyclesof.htm



Software - QRG home

CyclePad Software

Traditional Installer (32-bit versions of Windows)

This file will extract into a number of smaller files. First into a readme and another self-extractor, then into a bunch of files, including Setup.exe, which you will run to do actual installation. You may want to put it into a temporary directory prior to installation. After Setup.exe has run, the files in the temporary directory may be deleted.

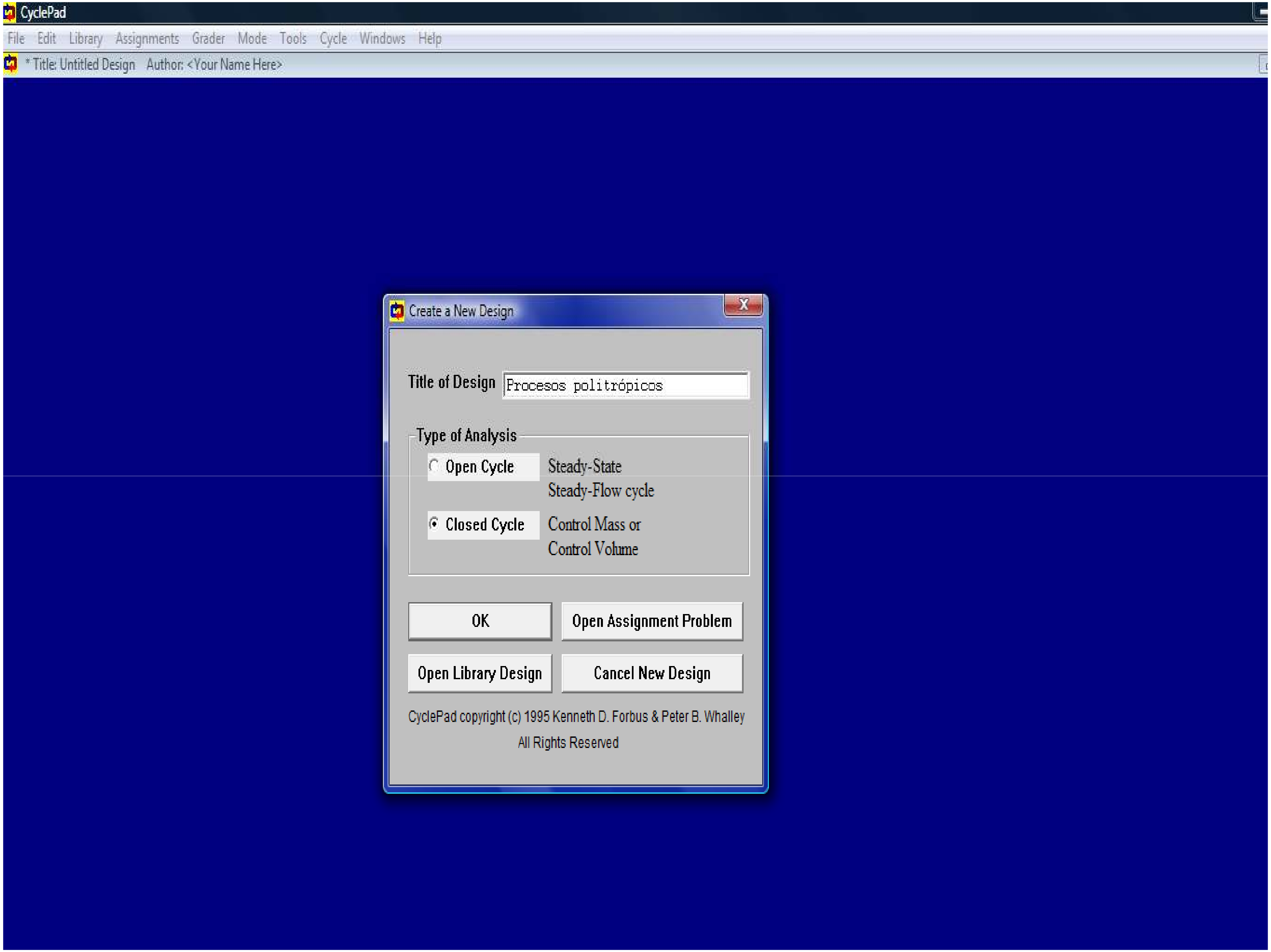
Download CyclePad v2.0 June 2001 (self-extracting archive 3.2MB)

Zip Archive for 64-bit versions of Windows

The installer above only works with 32 bit versions of Windows. For 64 bit versions, you will have to download the zip archive below. To install from the zip archive, unp it under some directory (e.g., c:\) and double-click cpad.exe to start the program. Important notes:

1. Please do not install it under Program Files, because Vista and Windows 7 are cranky about programs making changes there, and parts of CyclePad are likely to not v properly if you do that.
2. The help system uses the traditional Windows help system. If you click on help menu entries that need it, a Microsoft-provided dialog will appear that will take you t page to install the appropriate program. We are not allowed to redistibute this program by Microsoft; we apologize for the inconvenience.

Download zip archive for installing CyclePad on 64 bit machines


CyclePad
File Edit Library Assignments Grader Mode Tools Cycle Windows Help
* Title: Untitled Design Author: <Your Name Here>
Create a New Design
Title of Design
Procesos politrópicos
Type of Analysis
Open Cycle
Steady-State
Steady-Flow cycle
Closed Cycle
Control Mass or
Control Volume
OK
Open Assignment Problem
Open Library Design
Cancel New Design
CyclePad copyright (c) 1995 Kenneth D. Forbus & Peter B. Whalley
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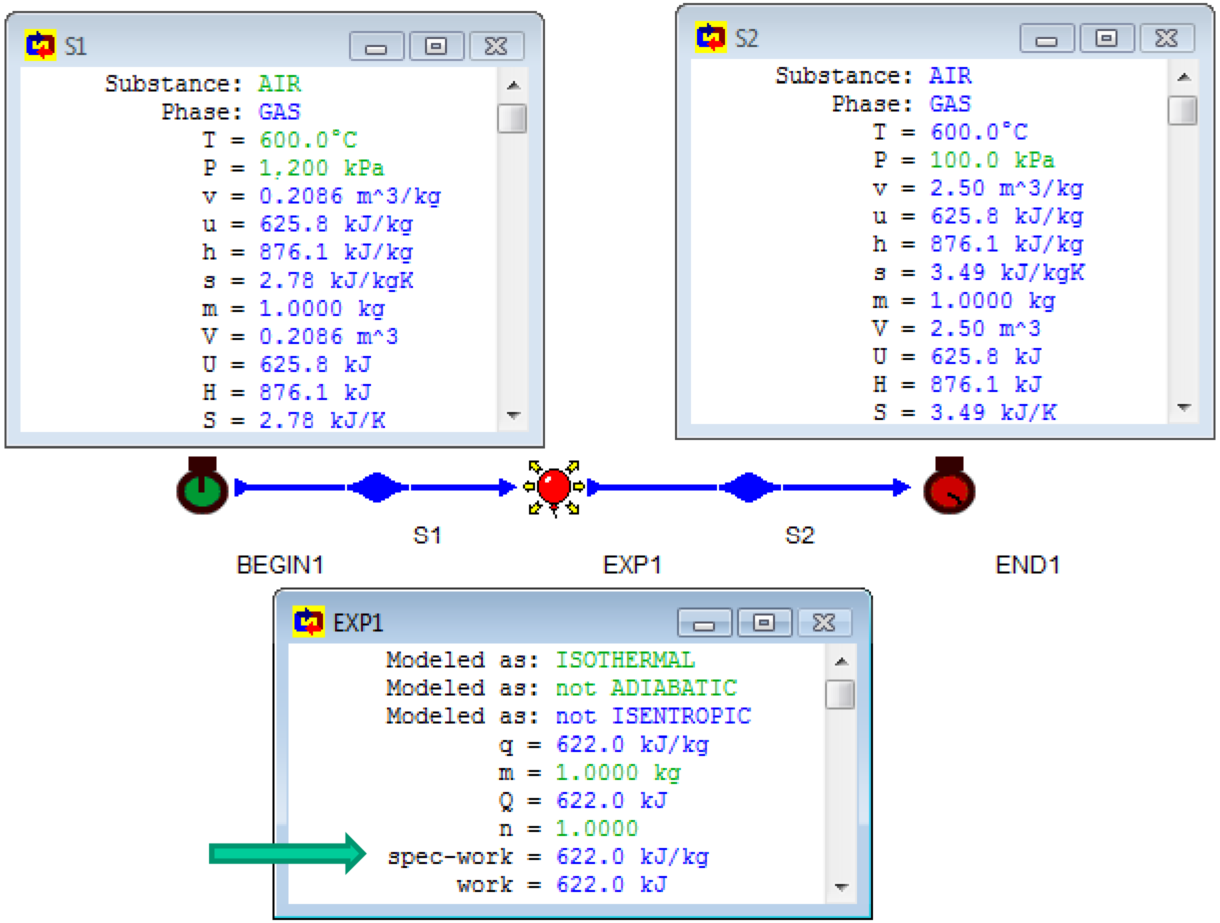
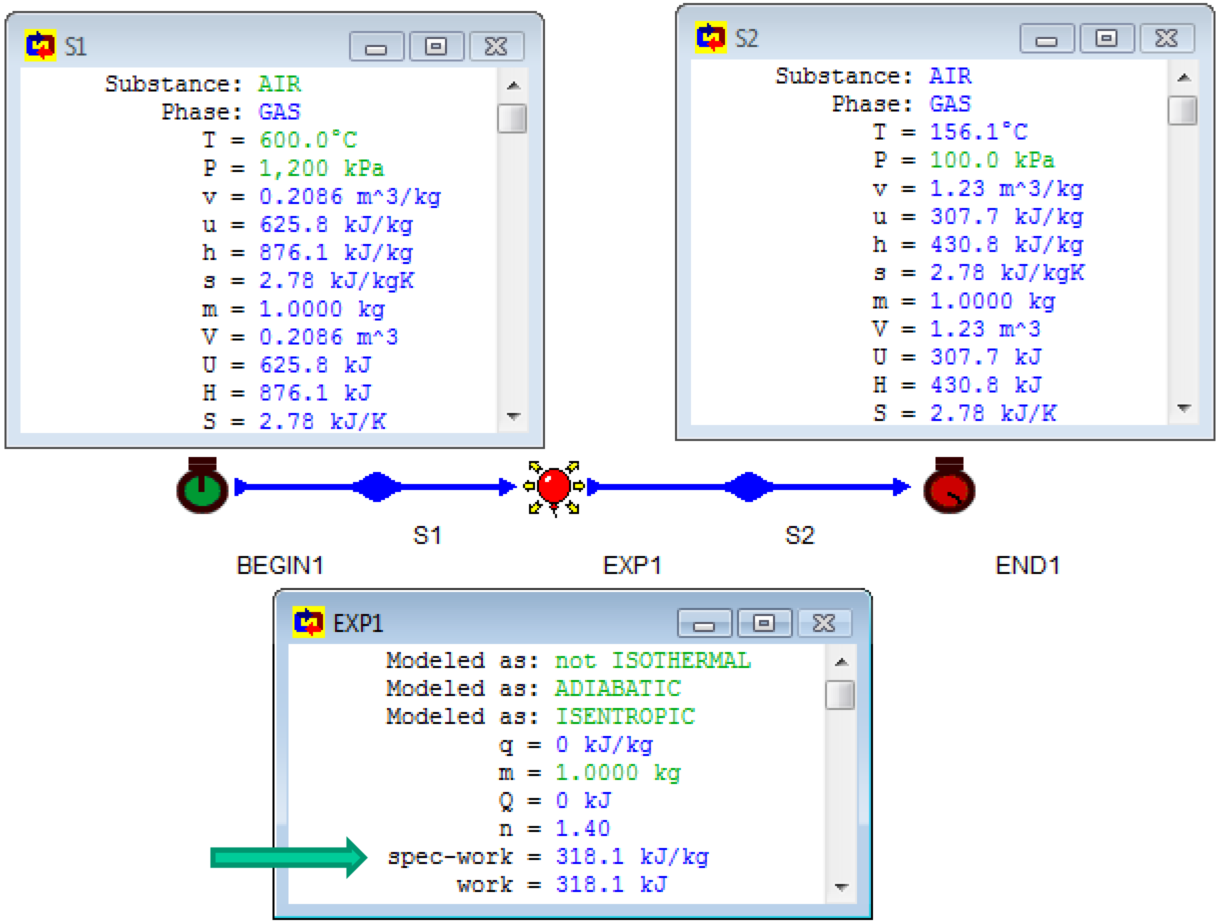
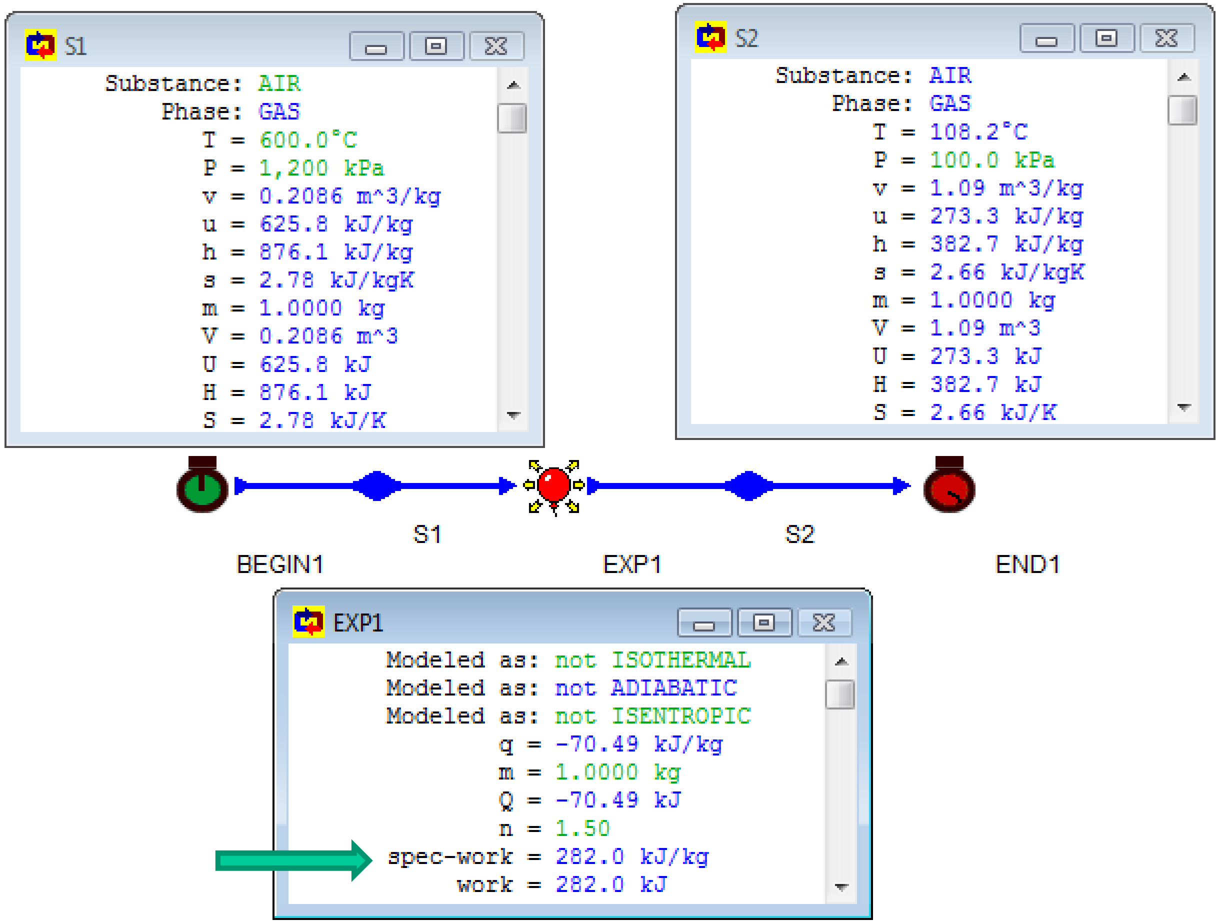
Proceso de expansión politrópico reversible en un sistema cerrado

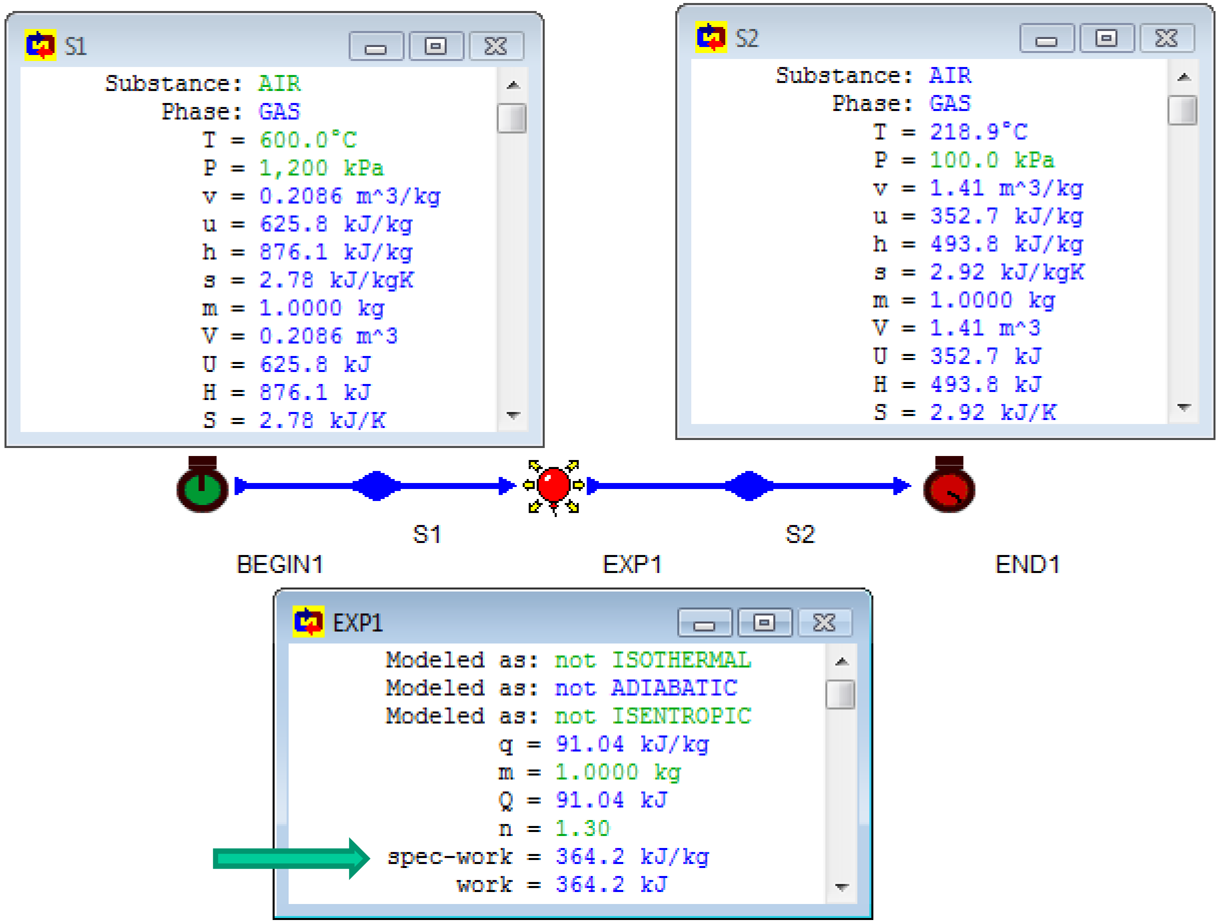


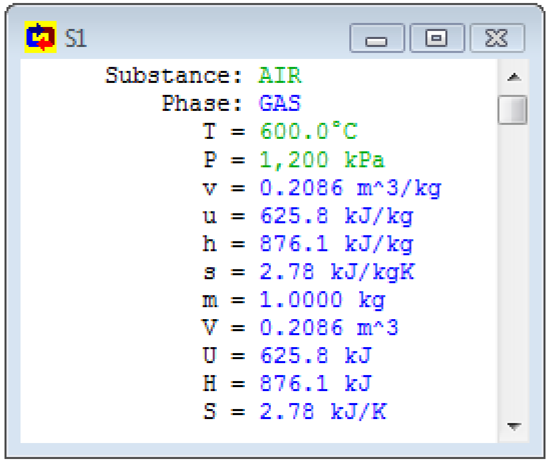
$$w_{12} = \int_{1}^{2} P\,dv = \int_{v_1}^{v_2} K \frac{dv}{v} = K \ln \frac{v_2}{v_1} = R\,T \ln \frac{v_2}{v_1} = R\,T \ln \frac{P_1}{P_2}$$

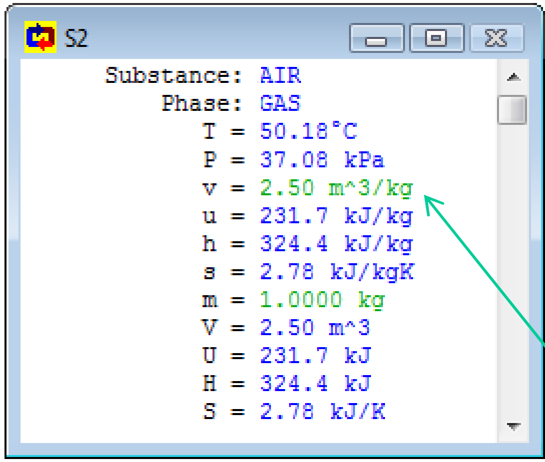

S1
Substance: AIR
Phase: GAS
T = 600.0°C
P = 1,200 kPa
v = 0.2086 m^3/kg
u = 625.8 kJ/kg
h = 876.1 kJ/kg
s = 2.78 kJ/kgK
m = 1.0000 kg
V = 0.2086 m^3
U = 625.8 kJ
H = 876.1 kJ
S = 2.78 kJ/K
S2
Substance: AIR
Phase: GAS
T = 156.1°C
P = 100.0 kPa
v = 1.23 m^3/kg
u = 307.7 kJ/kg
h = 430.8 kJ/kg
s = 2.78 kJ/kgK
m = 1.0000 kg
V = 1.23 m^3
U = 307.7 kJ
H = 430.8 kJ
S = 2.78 kJ/K
S1
S2
BEGIN1
EXP1
END1
EXP1
Modeled as: not ISOTHERMAL
Modeled as: ADIABATIC
Modeled as: ISENTROPIC
q = 0 kJ/kg
m = 1.0000 kg
Q = 0 kJ
n = 1.40
spec-work = 318.1 kJ/kg
work = 318.1 kJ



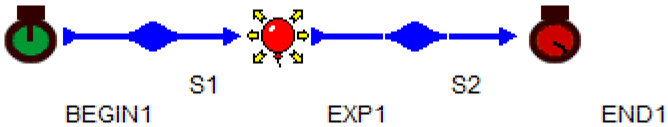
S1
Substance: AIR
Phase: GAS
T = 600.0°C
P = 1,200 kPa
v = 0.2086 m^3/kg
u = 625.8 kJ/kg
h = 876.1 kJ/kg
s = 2.78 kJ/kgK
m = 1.0000 kg
V = 0.2086 m^3
U = 625.8 kJ
H = 876.1 kJ
S = 2.78 kJ/K
S2
Substance: AIR
Phase: GAS
T = 108.2°C
P = 100.0 kPa
v = 1.09 m^3/kg
u = 273.3 kJ/kg
h = 382.7 kJ/kg
s = 2.66 kJ/kgK
m = 1.0000 kg
V = 1.09 m^3
U = 273.3 kJ
H = 382.7 kJ
S = 2.66 kJ/K
S1
S2
BEGIN1
EXP1
END1
EXP1
Modeled as: not ISOTHERMAL
Modeled as: not ADIABATIC
Modeled as: not ISENTROPIC
q = -70.49 kJ/kg
m = 1.0000 kg
Q = -70.49 kJ
n = 1.50
spec-work = 282.0 kJ/kg
work = 282.0 kJ

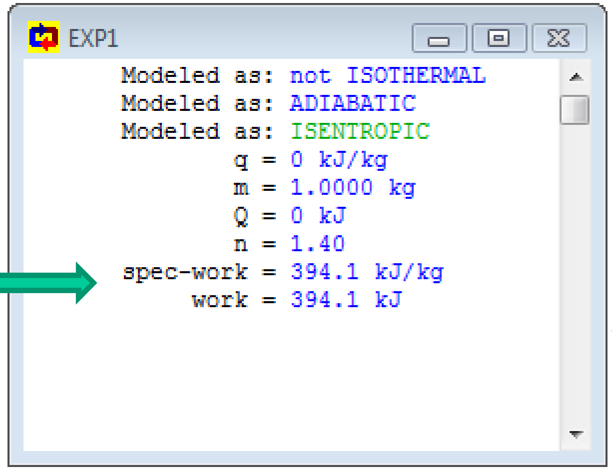

S1
Substance: AIR
Phase: GAS
T = 600.0°C
P = 1,200 kPa
v = 0.2086 m^3/kg
u = 625.8 kJ/kg
h = 876.1 kJ/kg
s = 2.78 kJ/kgK
m = 1.0000 kg
V = 0.2086 m^3
U = 625.8 kJ
H = 876.1 kJ
S = 2.78 kJ/K
S2
Substance: AIR
Phase: GAS
T = 218.9°C
P = 100.0 kPa
v = 1.41 m^3/kg
u = 352.7 kJ/kg
h = 493.8 kJ/kg
s = 2.92 kJ/kgK
m = 1.0000 kg
V = 1.41 m^3
U = 352.7 kJ
H = 493.8 kJ
S = 2.92 kJ/K
S1
S2
BEGIN1
EXP1
END1
EXP1
Modeled as: not ISOTHERMAL
Modeled as: not ADIABATIC
Modeled as: not ISENTROPIC
q = 91.04 kJ/kg
m = 1.0000 kg
Q = 91.04 kJ
n = 1.30
spec-work = 364.2 kJ/kg
work = 364.2 kJ





Igual v que el caso isotermo

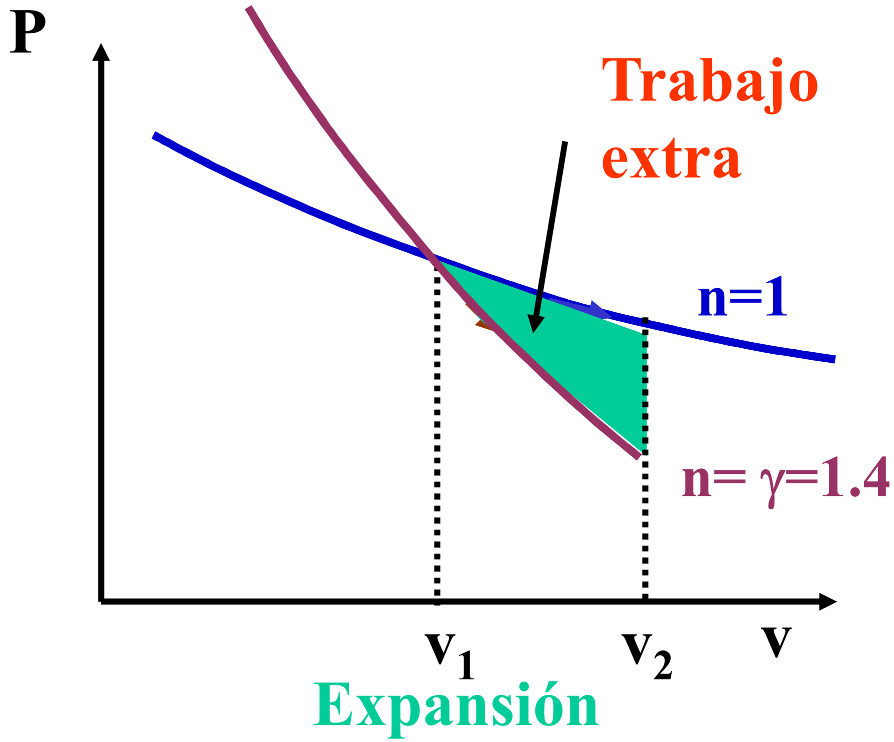




Se obtiene menor trabajo de expansión que el caso isotermo (ver gráfica final)

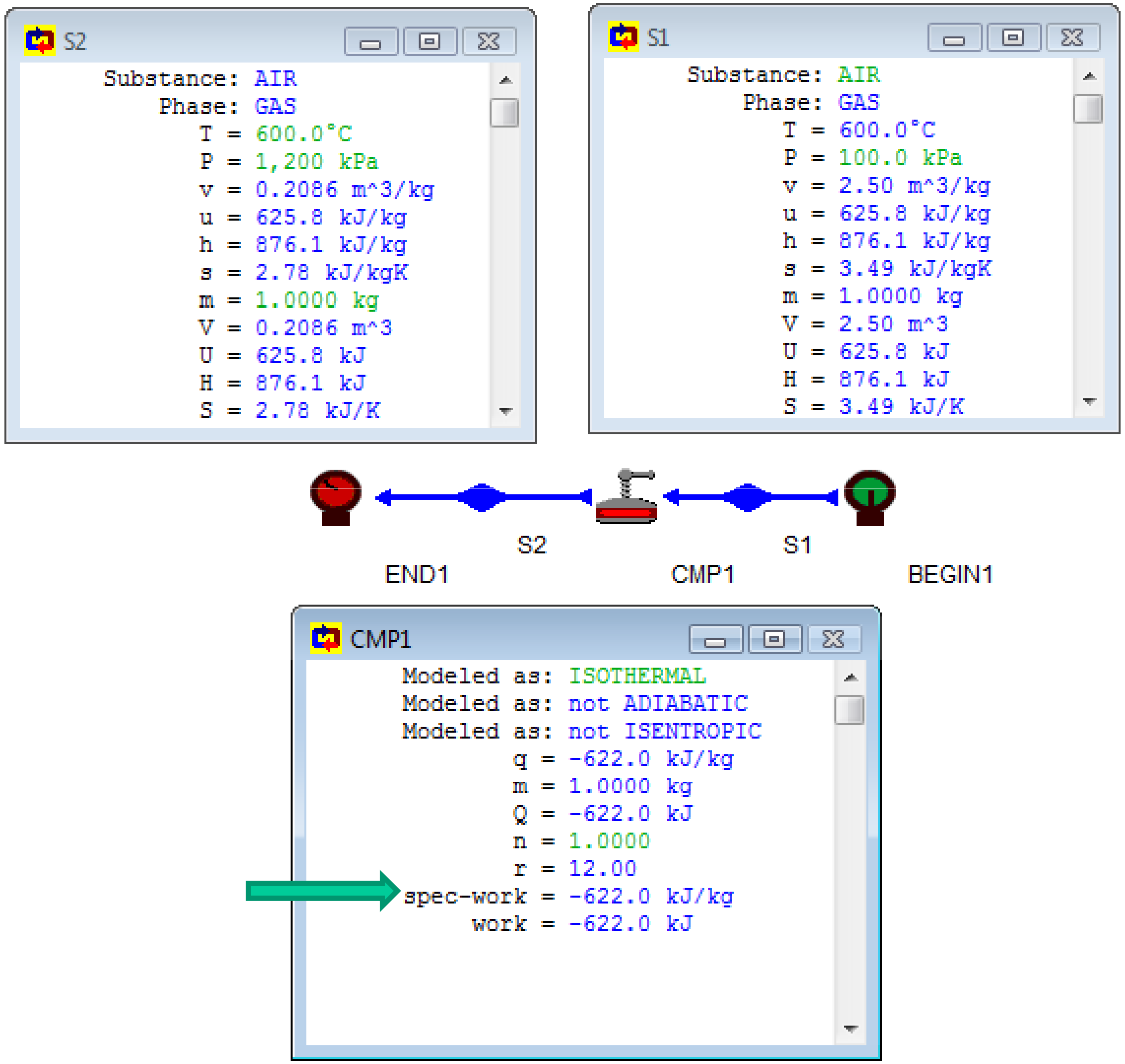
Comparación: Trabajo de expansión y compresión

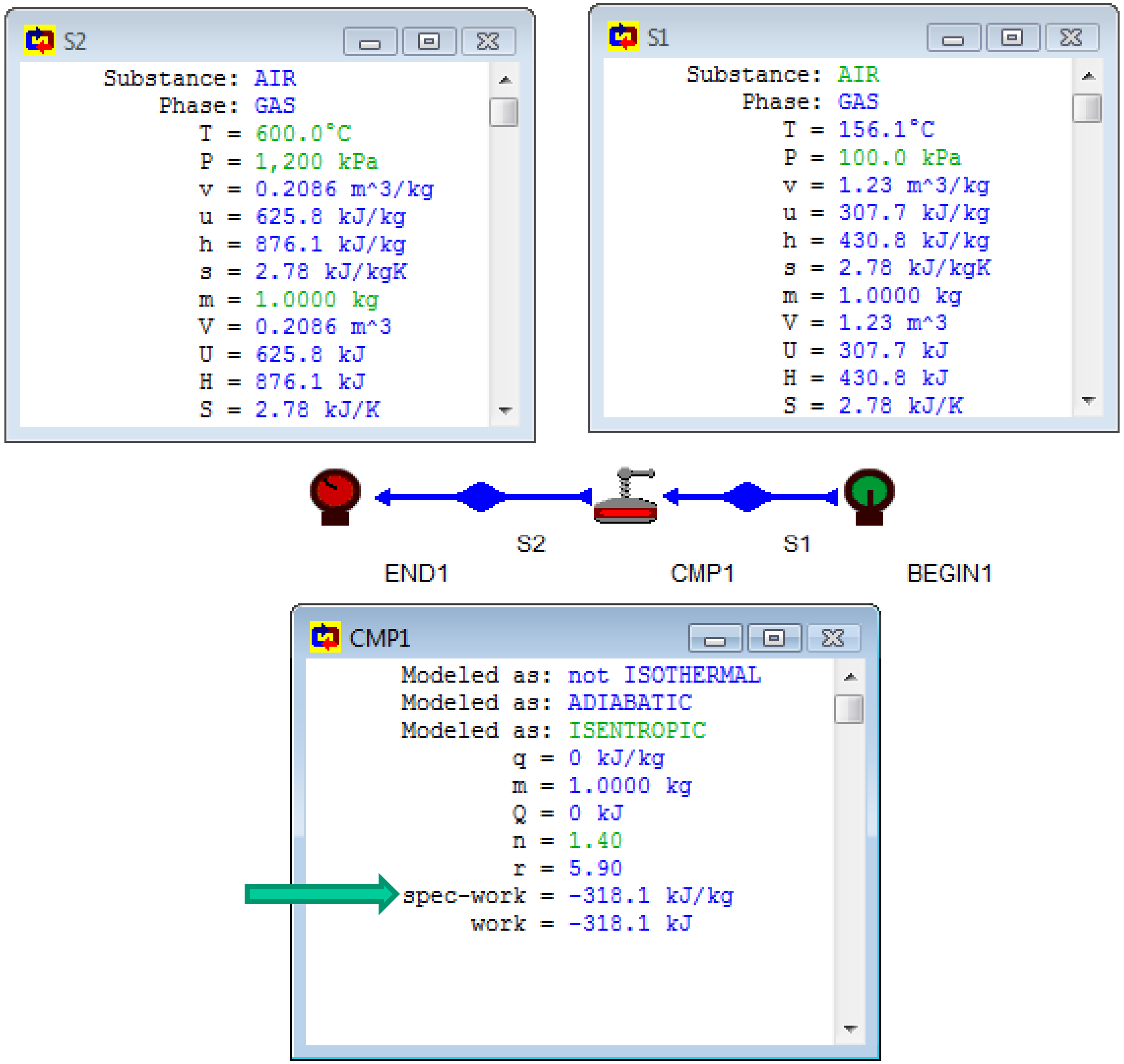
Procesos politrópicos $\Rightarrow$ $$w_{12} = \frac{1}{1-n}\left(P_2 v_2 - P_1 v_1\right)$$

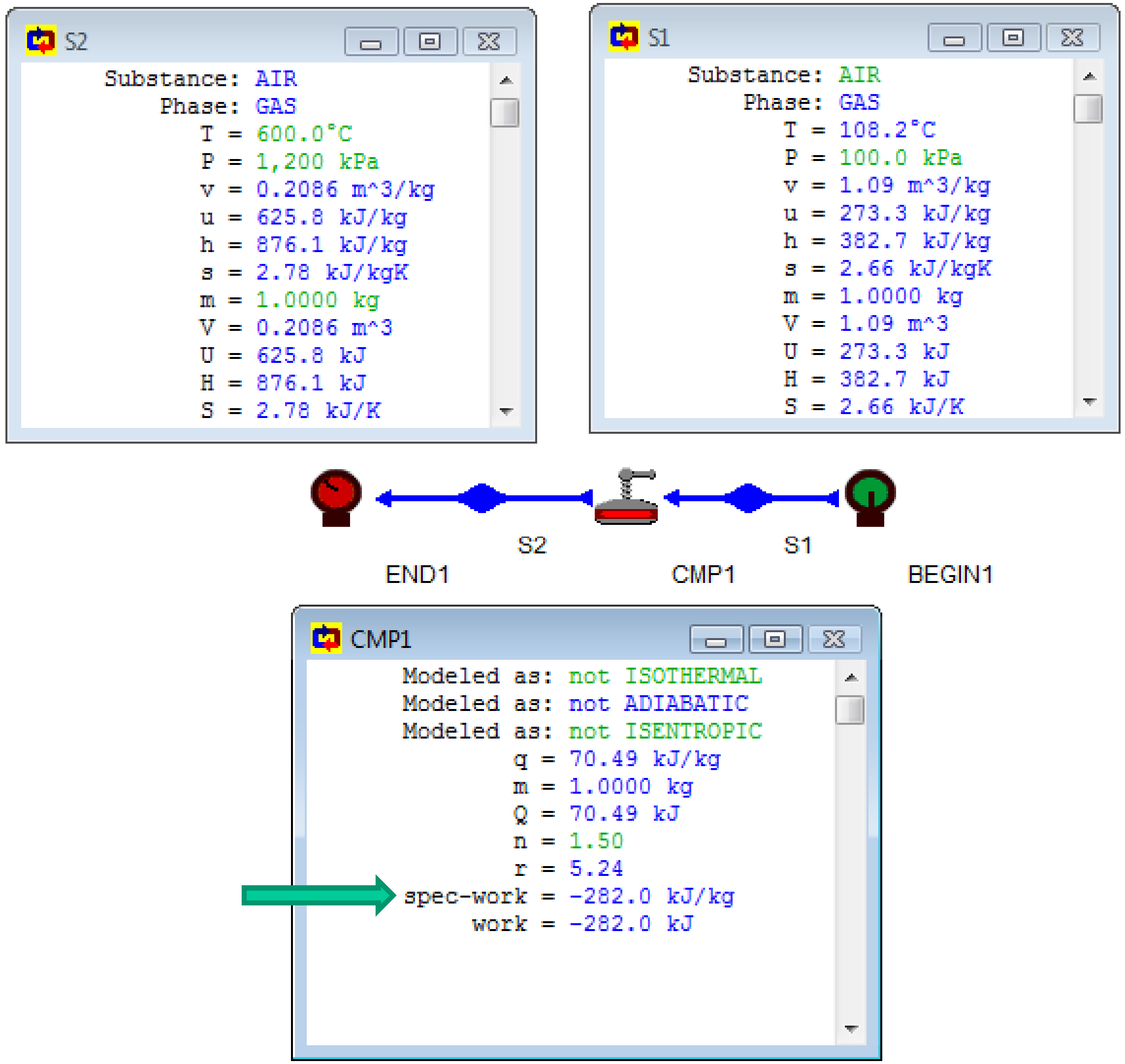


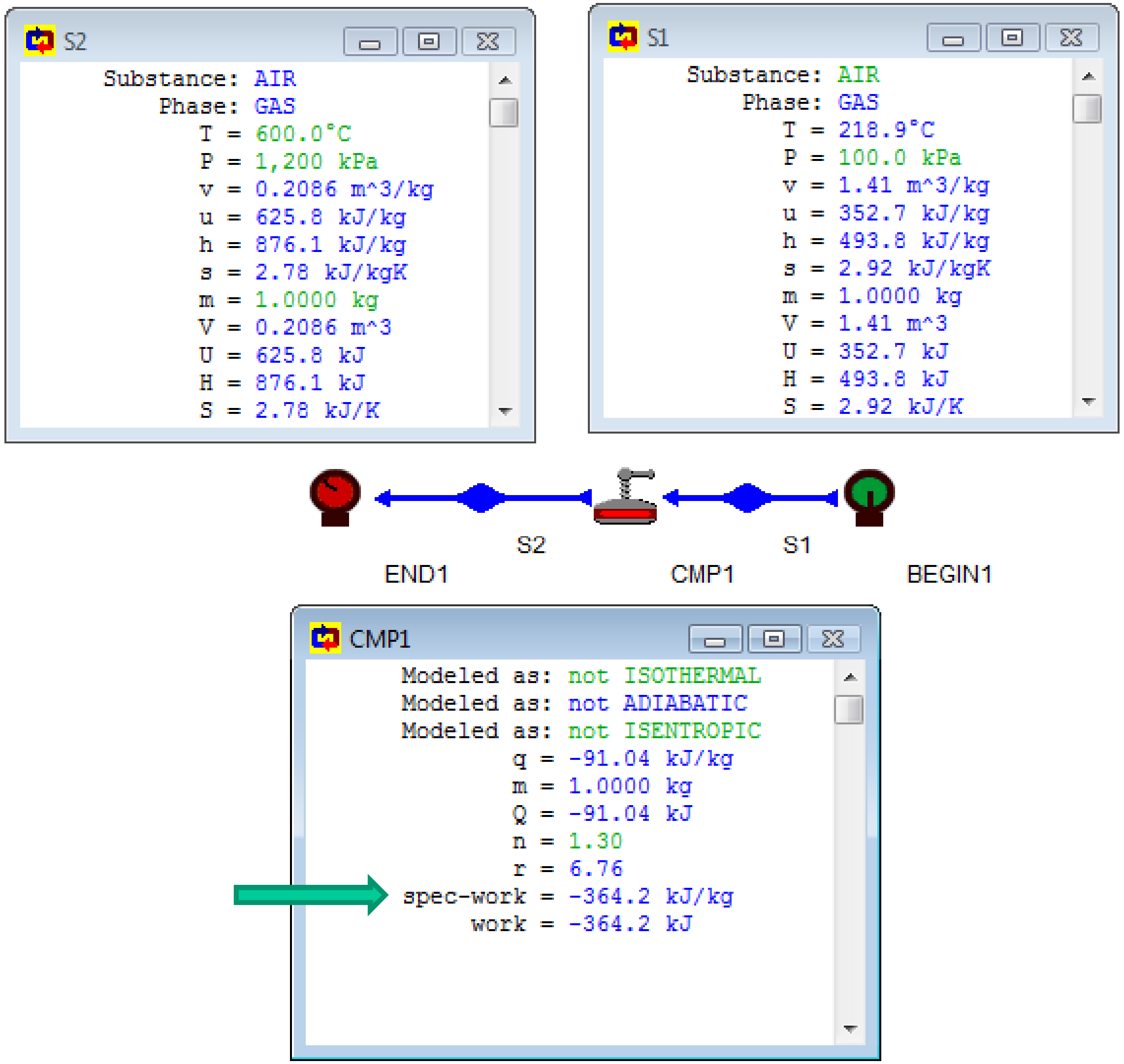
Interesa que el proceso se haga isotérmicamente

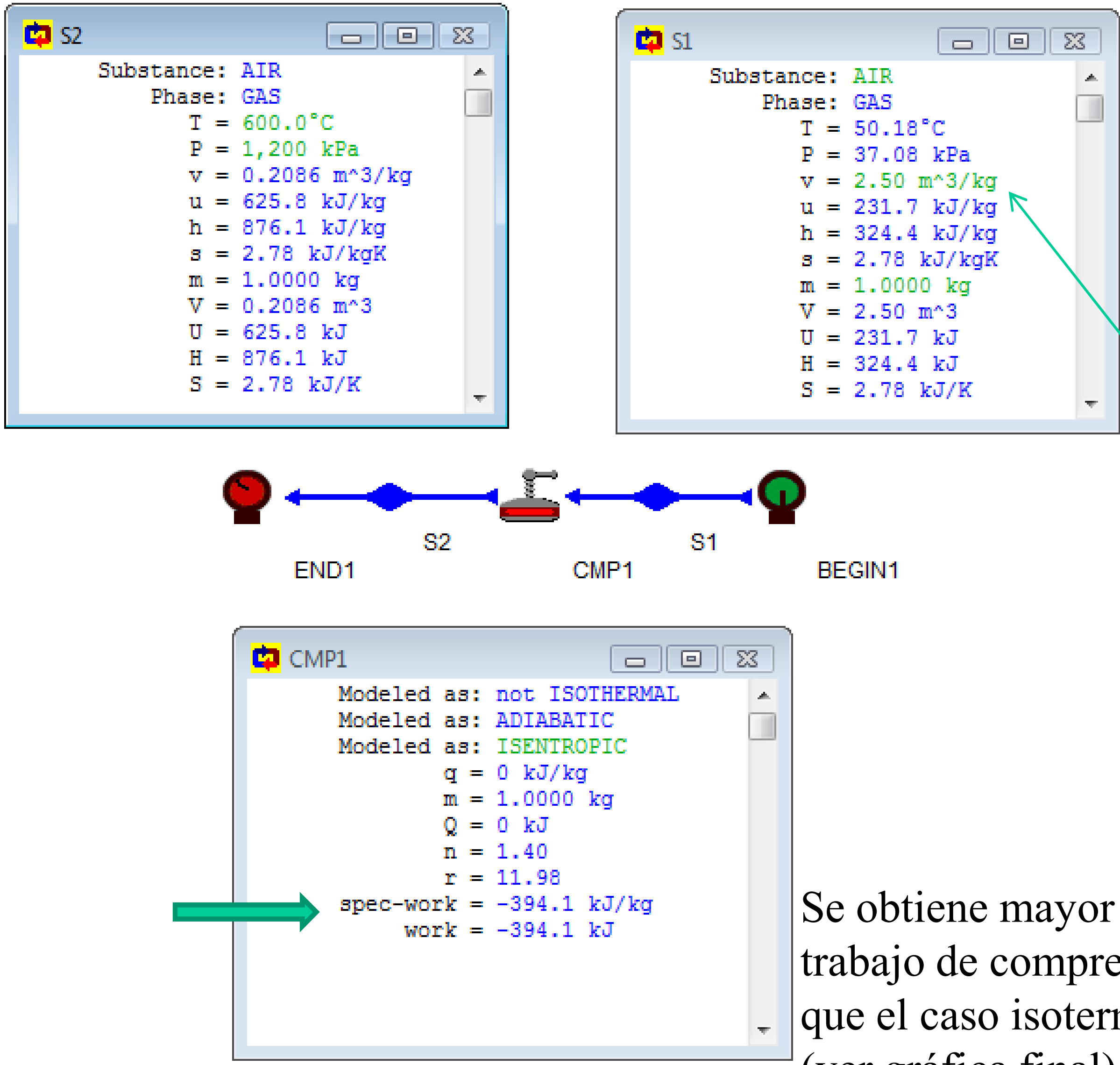
Proceso de compresión politrópico reversible en un sistema cerrado




S2
Substance: AIR
Phase: GAS
T = 600.0°C
P = 1,200 kPa
v = 0.2086 m^3/kg
u = 625.8 kJ/kg
h = 876.1 kJ/kg
s = 2.78 kJ/kgK
m = 1.0000 kg
V = 0.2086 m^3
U = 625.8 kJ
H = 876.1 kJ
S = 2.78 kJ/K
S1
Substance: AIR
Phase: GAS
T = 156.1°C
P = 100.0 kPa
v = 1.23 m^3/kg
u = 307.7 kJ/kg
h = 430.8 kJ/kg
s = 2.78 kJ/kgK
m = 1.0000 kg
V = 1.23 m^3
U = 307.7 kJ
H = 430.8 kJ
S = 2.78 kJ/K
S2
S1
END1
CMP1
BEGIN1
CMP1
Modeled as: not ISOTHERMAL
Modeled as: ADIABATIC
Modeled as: ISENTROPIC
q = 0 kJ/kg
m = 1.0000 kg
Q = 0 kJ
n = 1.40
r = 5.90
spec-work = -318.1 kJ/kg
work = -318.1 kJ


S2
Substance: AIR
Phase: GAS
T = 600.0°C
P = 1,200 kPa
v = 0.2086 m^3/kg
u = 625.8 kJ/kg
h = 876.1 kJ/kg
s = 2.78 kJ/kgK
m = 1.0000 kg
V = 0.2086 m^3
U = 625.8 kJ
H = 876.1 kJ
S = 2.78 kJ/K
S1
Substance: AIR
Phase: GAS
T = 108.2°C
P = 100.0 kPa
v = 1.09 m^3/kg
u = 273.3 kJ/kg
h = 382.7 kJ/kg
s = 2.66 kJ/kgK
m = 1.0000 kg
V = 1.09 m^3
U = 273.3 kJ
H = 382.7 kJ
S = 2.66 kJ/K
S2
S1
END1
CMP1
BEGIN1
CMP1
Modeled as: not ISOTHERMAL
Modeled as: not ADIABATIC
Modeled as: not ISENTROPIC
q = 70.49 kJ/kg
m = 1.0000 kg
Q = 70.49 kJ
n = 1.50
r = 5.24
spec-work = -282.0 kJ/kg
work = -282.0 kJ


S2
Substance: AIR
Phase: GAS
T = 600.0°C
P = 1,200 kPa
v = 0.2086 m^3/kg
u = 625.8 kJ/kg
h = 876.1 kJ/kg
s = 2.78 kJ/kgK
m = 1.0000 kg
V = 0.2086 m^3
U = 625.8 kJ
H = 876.1 kJ
S = 2.78 kJ/K
S1
Substance: AIR
Phase: GAS
T = 218.9°C
P = 100.0 kPa
v = 1.41 m^3/kg
u = 352.7 kJ/kg
h = 493.8 kJ/kg
s = 2.92 kJ/kgK
m = 1.0000 kg
V = 1.41 m^3
U = 352.7 kJ
H = 493.8 kJ
S = 2.92 kJ/K
S2
S1
END1
CMP1
BEGIN1
CMP1
Modeled as: not ISOTHERMAL
Modeled as: not ADIABATIC
Modeled as: not ISENTROPIC
q = -91.04 kJ/kg
m = 1.0000 kg
Q = -91.04 kJ
n = 1.30
r = 6.76
spec-work = -364.2 kJ/kg
work = -364.2 kJ

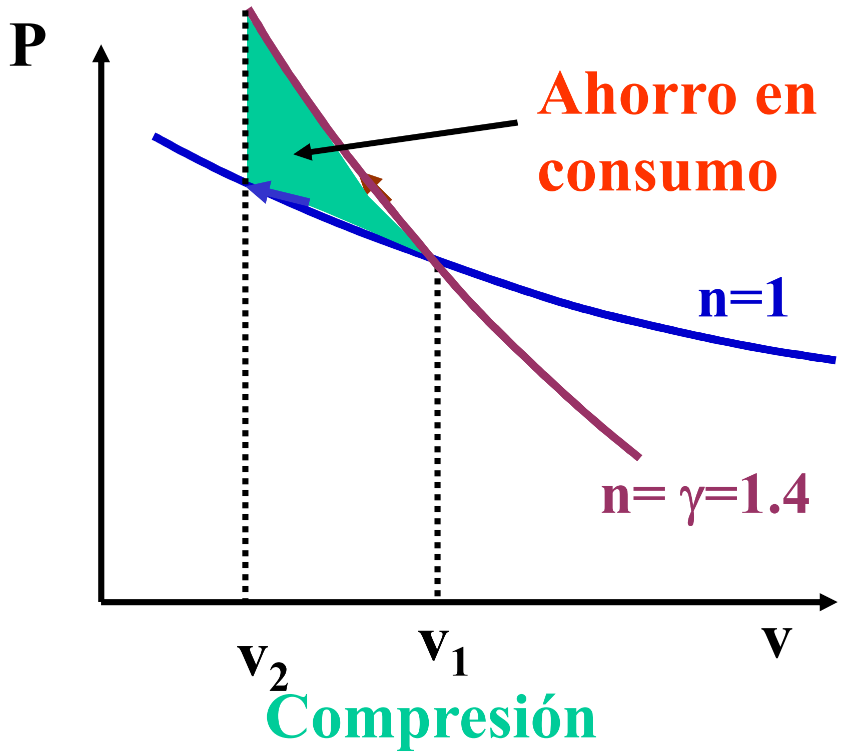


Igual v que el caso isotermo

Se obtiene mayor trabajo de compresión que el caso isotermo (ver gráfica final)

Comparación: Trabajo de expansión y compresión

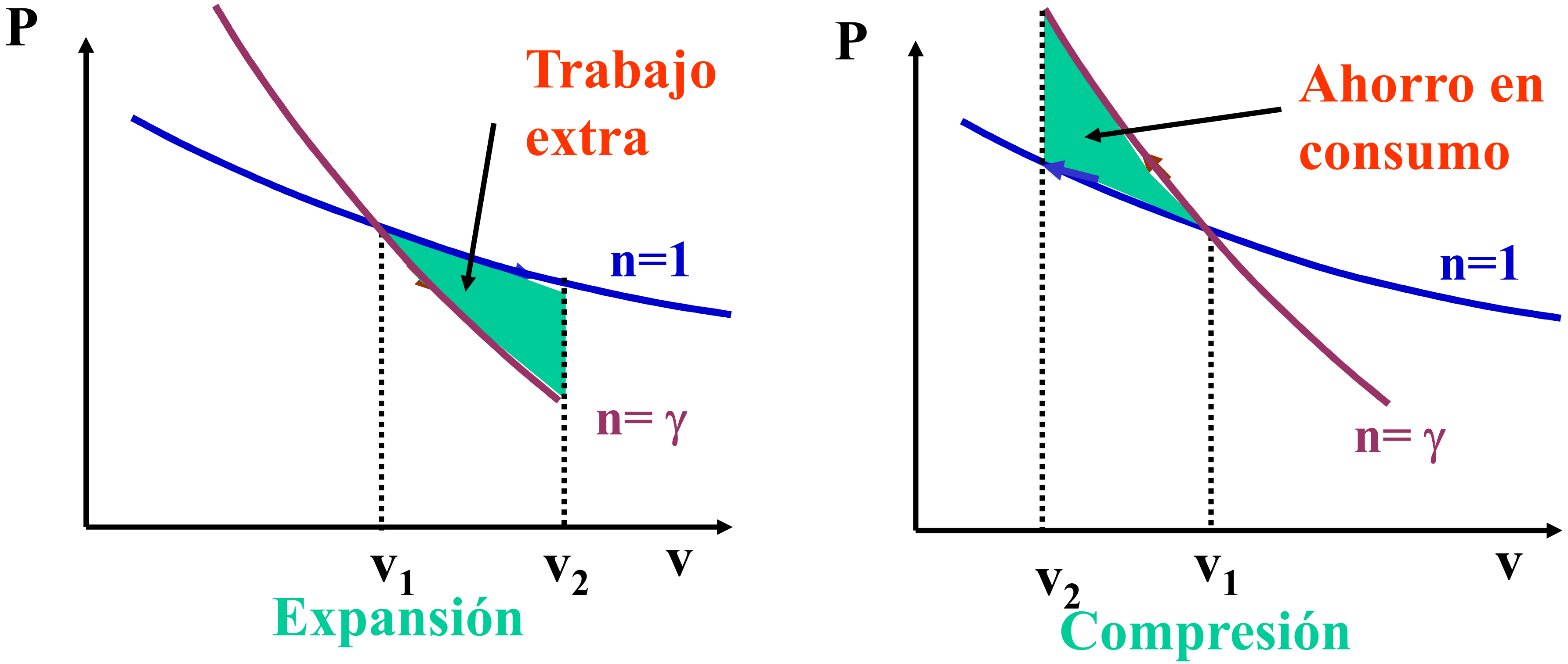
Procesos politrópicos $\Rightarrow$ $$w_{12} = \frac{1}{1-n}\left(P_2 v_2 - P_1 v_1\right)$$



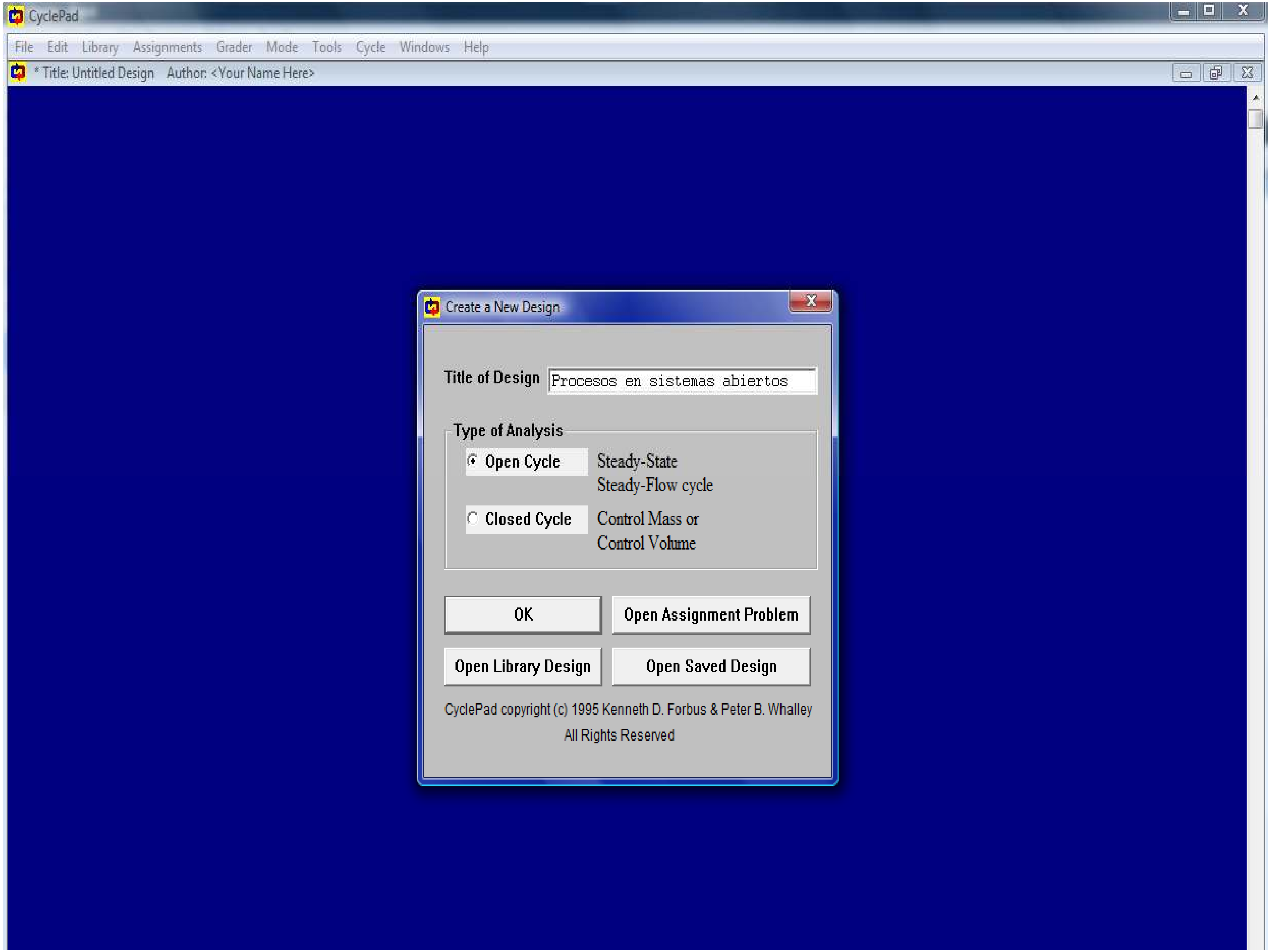
Interesa que el proceso se haga isotérmicamente

CONCLUSIÓN: Trabajo de expansión y compresión

Procesos politrópicos $\Rightarrow$ $$w_{12} = \frac{1}{1-n}\left(P_2 v_2 - P_1 v_1\right)$$



Interesa que ambos procesos se hagan sin variación de T


CyclePad
File Edit Library Assignments Grader Mode Tools Cycle Windows Help
* Title: Untitled Design Author: <Your Name Here>
Create a New Design
Title of Design
Procesos en sistemas abiertos
Type of Analysis
Open Cycle
Steady-State
Steady-Flow cycle
Closed Cycle
Control Mass or
Control Volume
OK
Open Assignment Problem
Open Library Design
Open Saved Design
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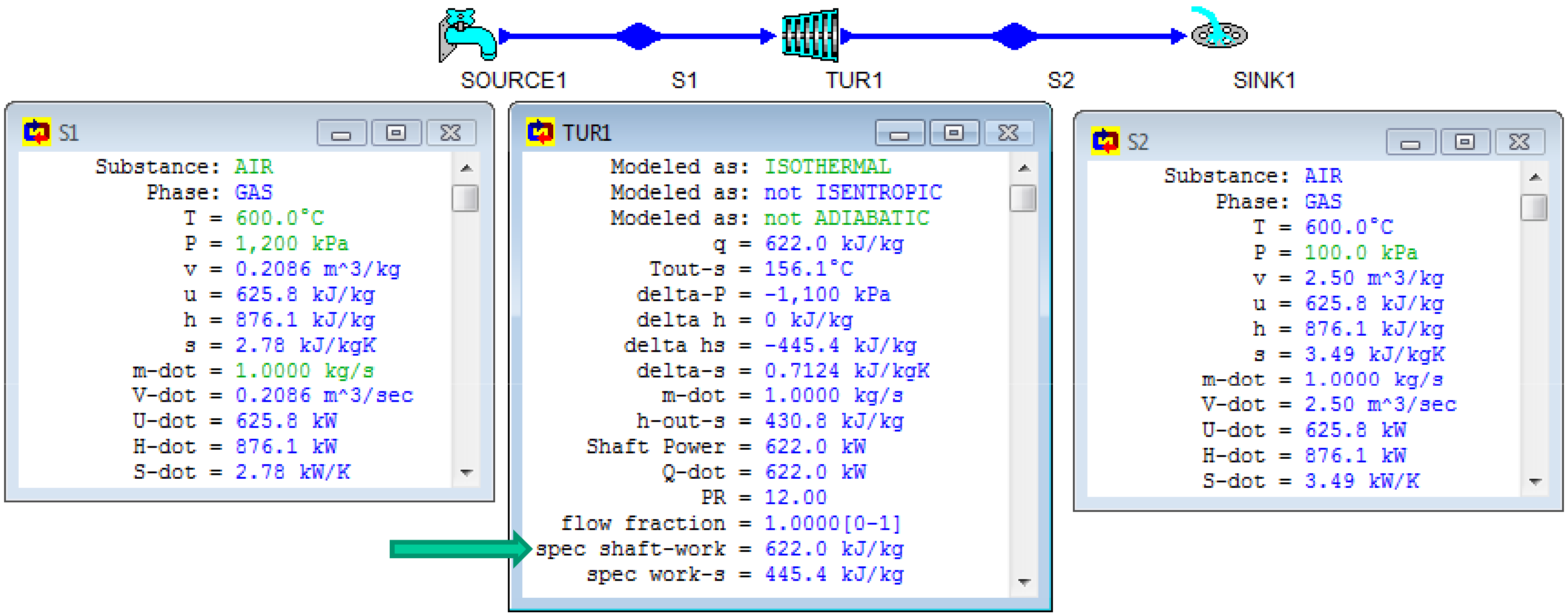
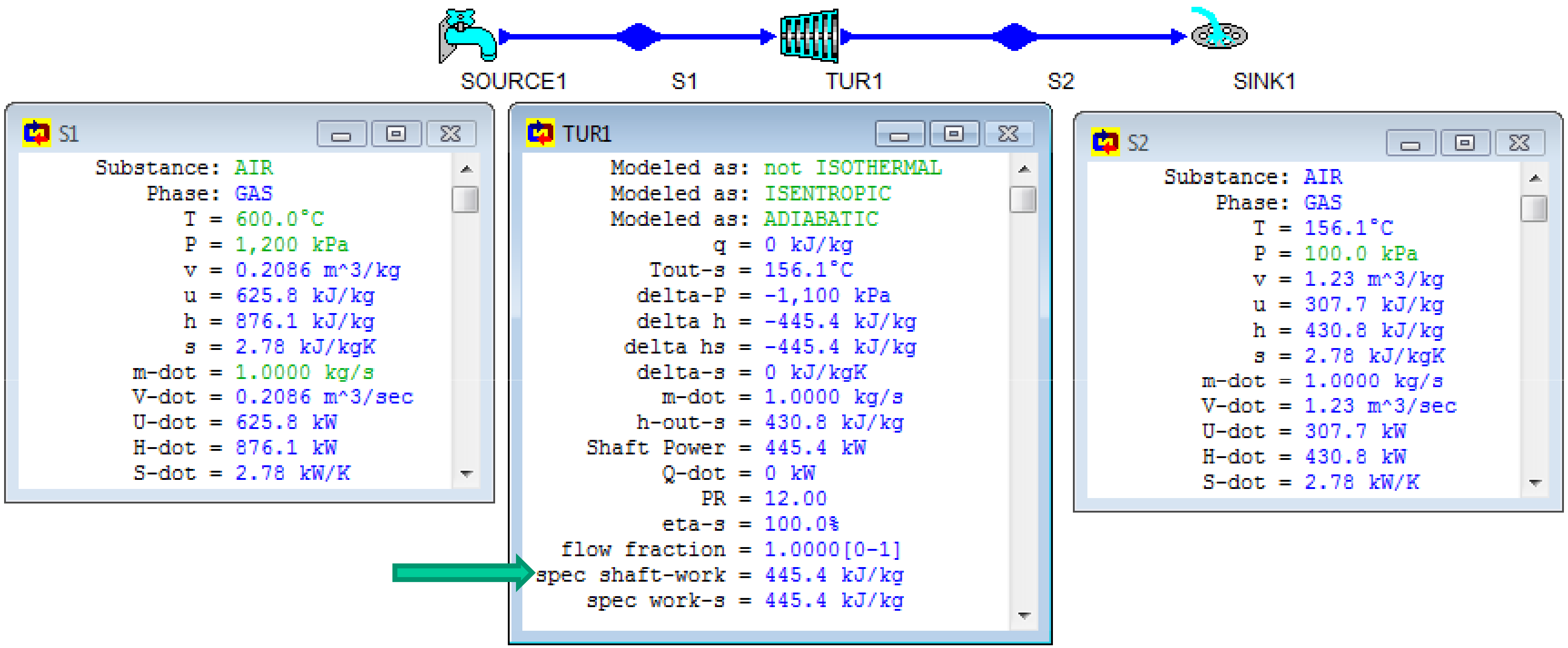
Proceso de expansión reversible en un sistema abierto



$$w_{12} = -\int_1^2 v\, dP = -\int_{V_1}^{V_2} K \frac{dP}{P^{1/n}} \underset{(n=1)}{=} -RT \ln \frac{P_2}{p_1} = RT \ln \frac{P_1}{P_2}$$

Coincide SC

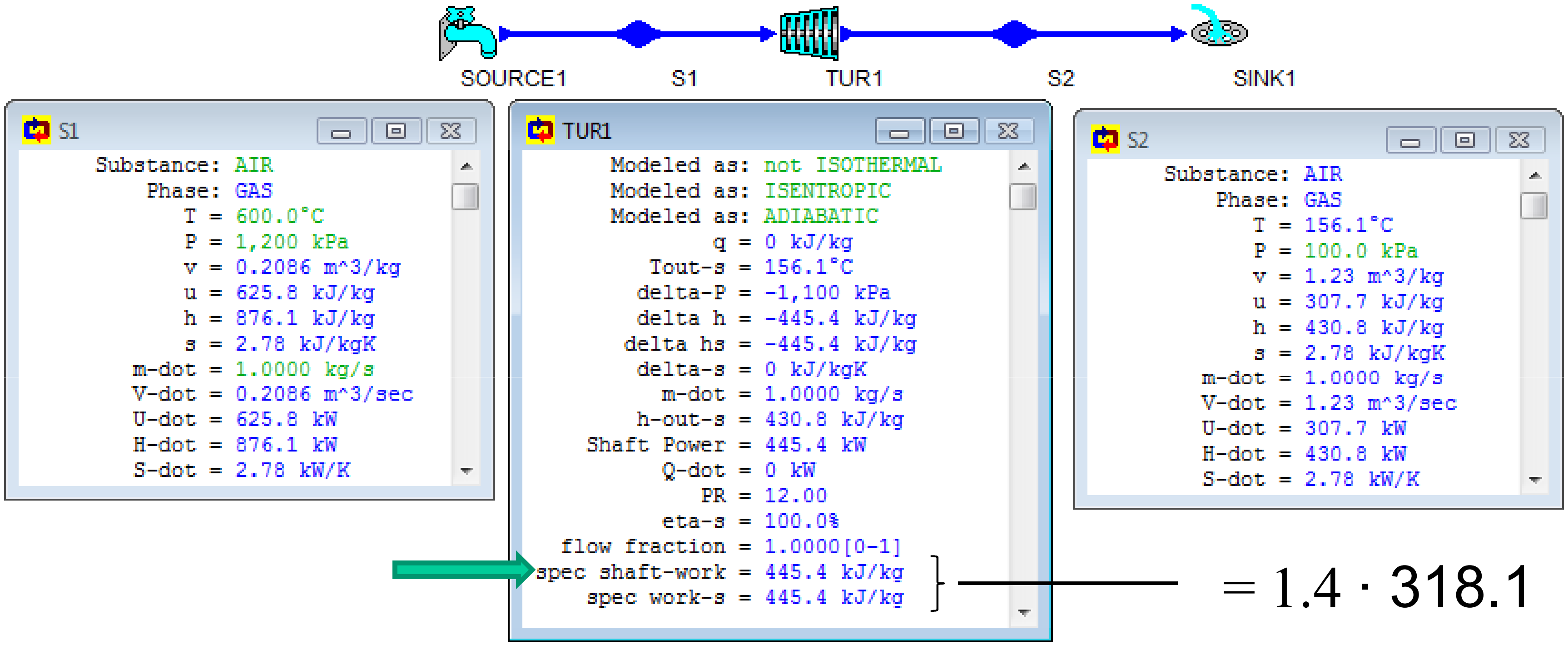
Proceso de expansión reversible en un sistema abierto



$$w_{12} = -\int_{1}^{2} v\, dP = -\int_{v_1}^{v_2} K \frac{dP}{P^{1/n}} = \frac{\gamma R}{(1-\gamma)} (T_2 - T_1)$$

($n=\gamma=1.4$)

Proceso de expansión reversible en un sistema abierto



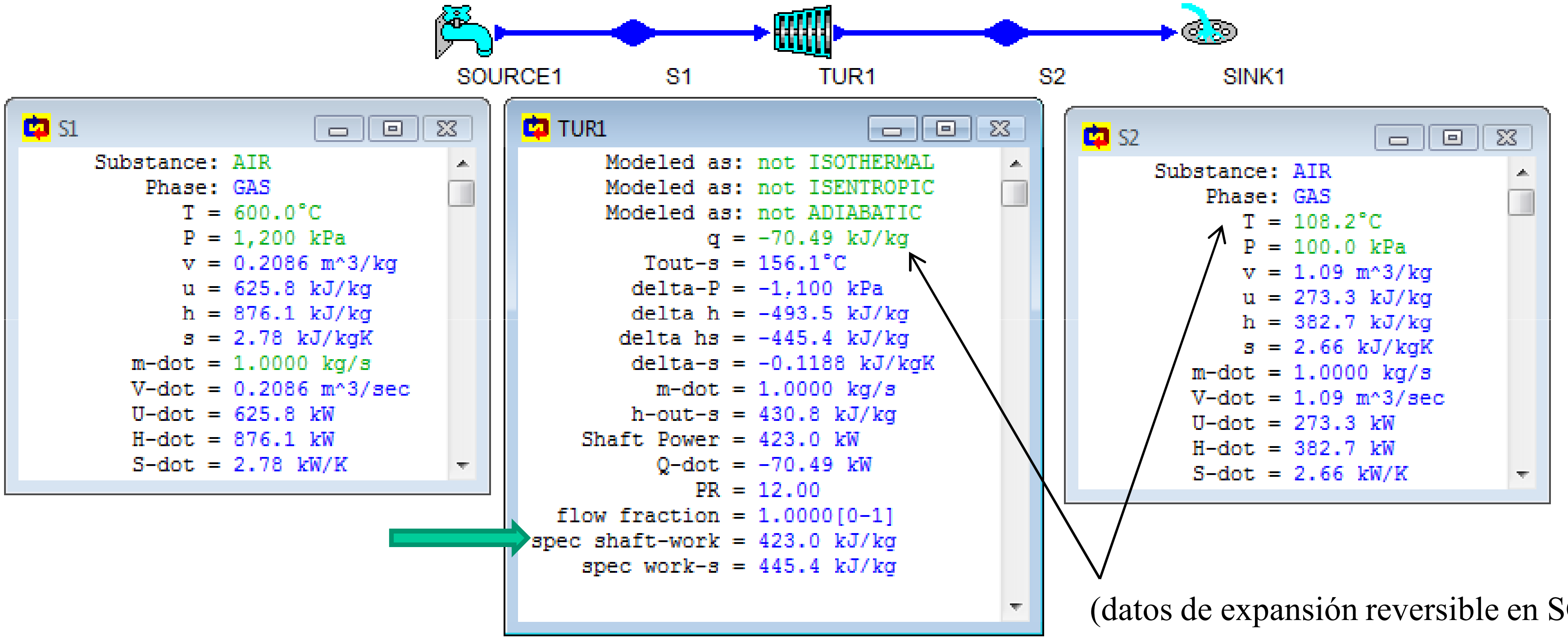
$= 1.4 \cdot 318.1$

$$w_{12} = -\int_1^2 v\, dP = -\int_{v_1}^{v_2} K \frac{dP}{P^{1/n}} = \frac{\gamma R}{(1-\gamma)} (T_2 - T_1) = \gamma \cdot w_{12(SC)}$$

$(n=\gamma)$

Proceso de expansión reversible en un sistema abierto

(comparación con expansión reversible en SC con n=1.5)

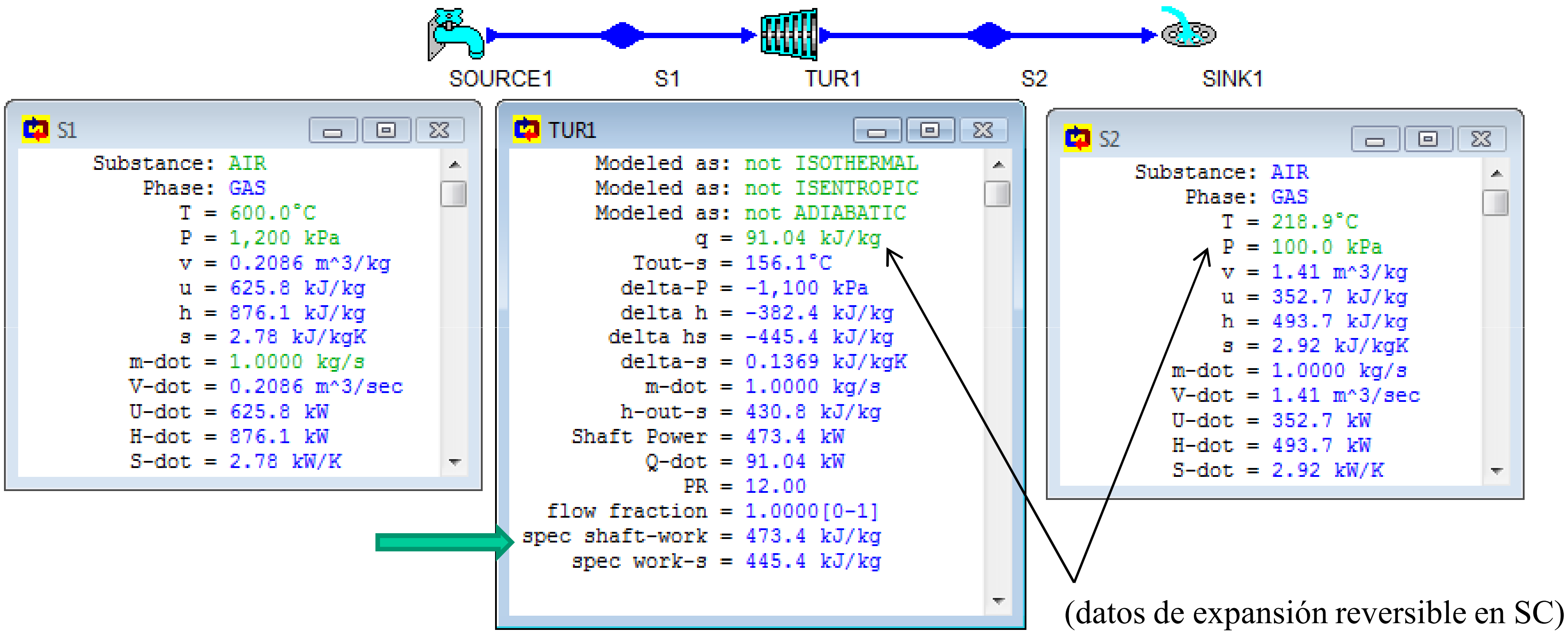


(datos de expansión reversible en SC)

$$w_{12}=\frac{n}{(1-n)}\left(P_2v_2 - P_1v_1 \right) = n\, w_{12(SC)} = 1.5 \cdot 282 = 423 \text{ kJ/kg}$$

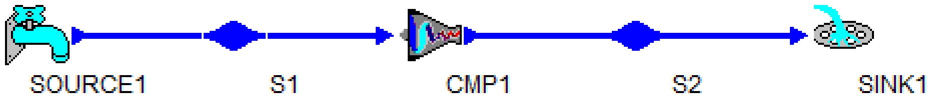
Proceso de expansión reversible en un sistema abierto

(comparación con expansión reversible en SC con n=1.3)



$$w_{12}=\frac{n}{(1-n)}\left(P_2v_2 - P_1v_1\right) = n\, w_{12(SC)} = 1.3 \cdot 364.2 = 473.4 \text{ kJ/kg}$$

Proceso de compresión reversible en un sistema abierto



S1

```
     Substance: AIR
         Phase: GAS
             T = 600.0°C
             P = 100.0 kPa
             v = 2.50 m^3/kg
             u = 625.8 kJ/kg
             h = 876.1 kJ/kg
             s = 3.49 kJ/kgK
         m-dot = 1.0000 kg/s
         V-dot = 2.50 m^3/sec
         U-dot = 625.8 kW
         H-dot = 876.1 kW
         S-dot = 3.49 kW/K
 flow fraction = 1.0000[0-1]
```

CMP1

```
   Modeled as: ISOTHERMAL
   Modeled as: not ADIABATIC
   Modeled as: not ISENTROPIC
   Modeled as: Make Assumption
             q = -622.0 kJ/kg
        Tout-s = 1,503°C
       delta-P = 1,100 kPa
       delta h = 0 kJ/kg
      delta hs = 905.9 kJ/kg
       delta-s = -0.7124 kJ/kgK
         m-dot = 1.0000 kg/s
       delta H = 0 kJ
       h-out-s = 1,782 kJ/kg
   Shaft Power = -622.0 kW
         Q-dot = -622.0 kW
            PR = 12.00
 flow fraction = 1.0000[0-1]
             r = 12.00
spec shaft-work = -622.0 kJ/kg
   spec work-s = -905.9 kJ/kg
```

S2

```
     Substance: AIR
         Phase: GAS
             T = 600.0°C
             P = 1,200 kPa
             v = 0.2086 m^3/kg
             u = 625.8 kJ/kg
             h = 876.1 kJ/kg
             s = 2.78 kJ/kgK
         m-dot = 1.0000 kg/s
         V-dot = 0.2086 m^3/sec
         U-dot = 625.8 kW
         H-dot = 876.1 kW
         S-dot = 2.78 kW/K
 flow fraction = 1.0000[0-1]
```

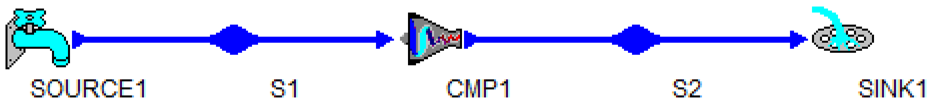
Proceso isoentrópico posee mayor consumo energético

$$w_{12} = -\int_{1}^{2} v\,dP = -\int_{v_1}^{v_2} K \frac{dP}{P^{1/n}} = -RT \ln \frac{P_2}{p_1} = RT \ln \frac{P_1}{P_2}$$

(n=1)

Coincide SC

Proceso de compresión reversible en un sistema abierto



S1

Substance:	AIR
Phase:	GAS
T =	108.2°C
P =	100.0 kPa
v =	1.09 m^3/kg
u =	273.3 kJ/kg
h =	382.7 kJ/kg
s =	2.66 kJ/kgK
m-dot =	1.0000 kg/s
V-dot =	1.09 m^3/sec
U-dot =	273.3 kW
H-dot =	382.7 kW
S-dot =	2.66 kW/K
flow fraction =	1.0000[0-1]

CMP1

Modeled as:	not NON-POLYTROPIC
Modeled as:	POLYTROPIC
Modeled as:	not ISOTHERMAL
Modeled as:	not ADIABATIC
Modeled as:	not ISENTROPIC
q =	70.49 kJ/kg
Tout-s =	502.6°C
delta-P =	1,100 kPa
delta h =	493.4 kJ/kg
delta hs =	395.7 kJ/kg
delta-s =	0.1187 kJ/kgK
m-dot =	1.0000 kg/s
delta H =	493.4 kJ
h-out-s =	778.4 kJ/kg
Shaft Power =	-423.0 kW
Q-dot =	70.49 kW
PR =	12.00
flow fraction =	1.0000[0-1]
n =	1.50
r =	5.24
spec shaft-work =	-423.0 kJ/kg
spec work-s =	-395.7 kJ/kg

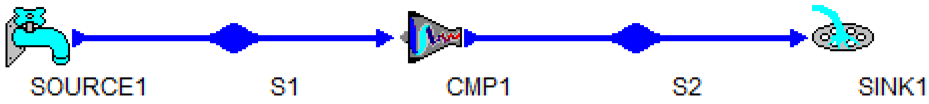
S2

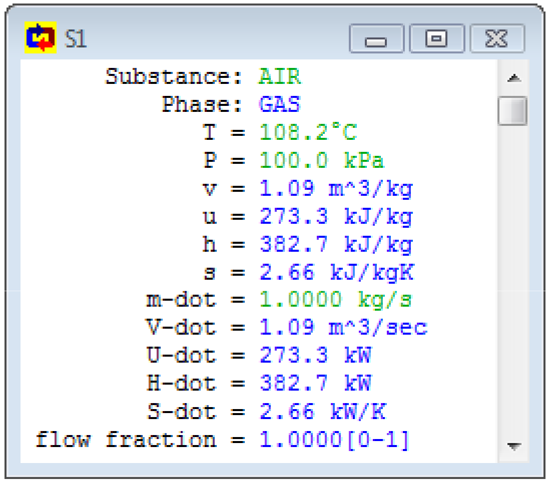
Substance:	AIR
Phase:	GAS
T =	600.0°C
P =	1,200 kPa
v =	0.2086 m^3/kg
u =	625.8 kJ/kg
h =	876.1 kJ/kg
s =	2.78 kJ/kgK
m-dot =	1.0000 kg/s
V-dot =	0.2086 m^3/sec
U-dot =	625.8 kW
H-dot =	876.1 kW
S-dot =	2.78 kW/K
flow fraction =	1.0000[0-1]

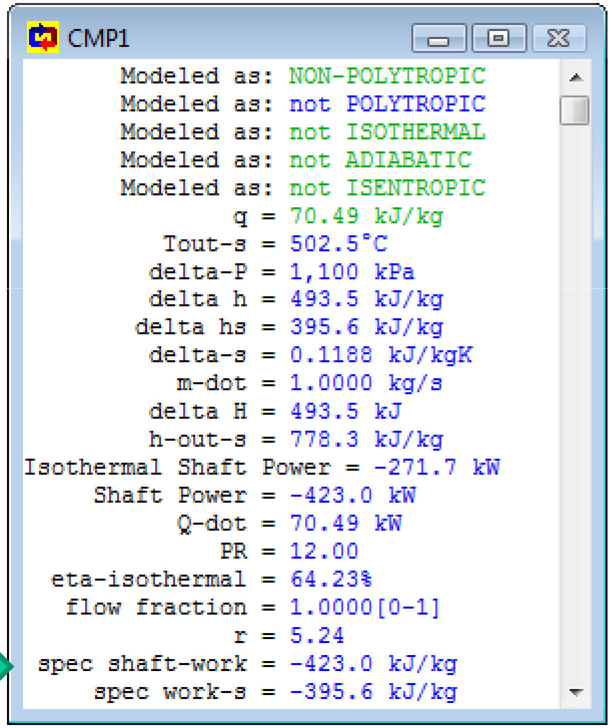
$$w_{12} = \frac{n}{(1-n)}(P_2v_2 - P_1v_1) = n\, w_{12(SC)} = 1.5 \cdot -282 = -423 \text{ kJ/kg}$$

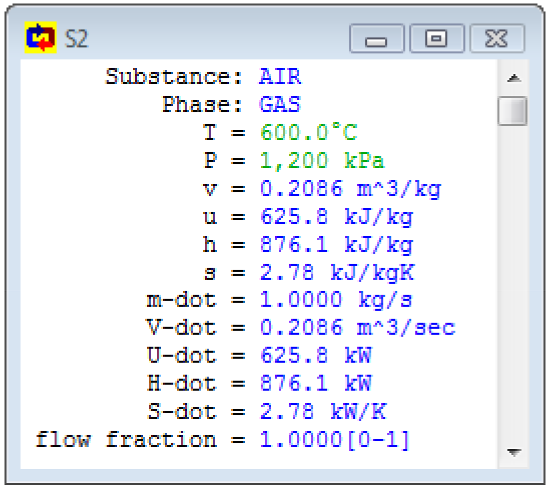
Proceso de compresión reversible en un sistema abierto

(otra combinación de datos de entrada)



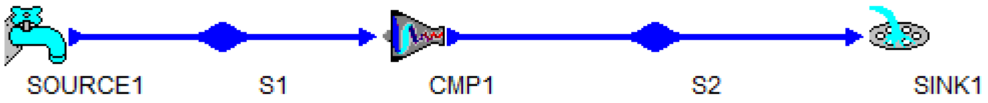


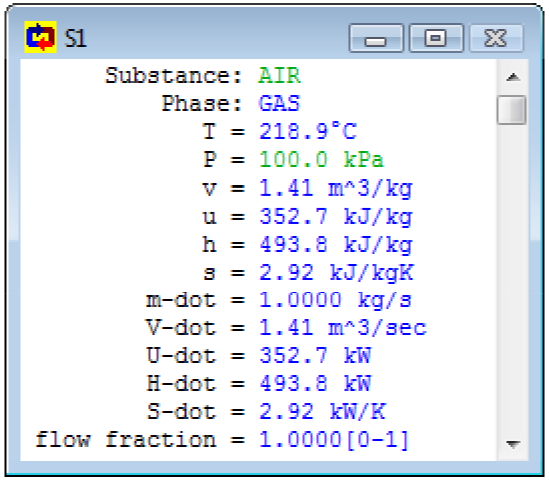


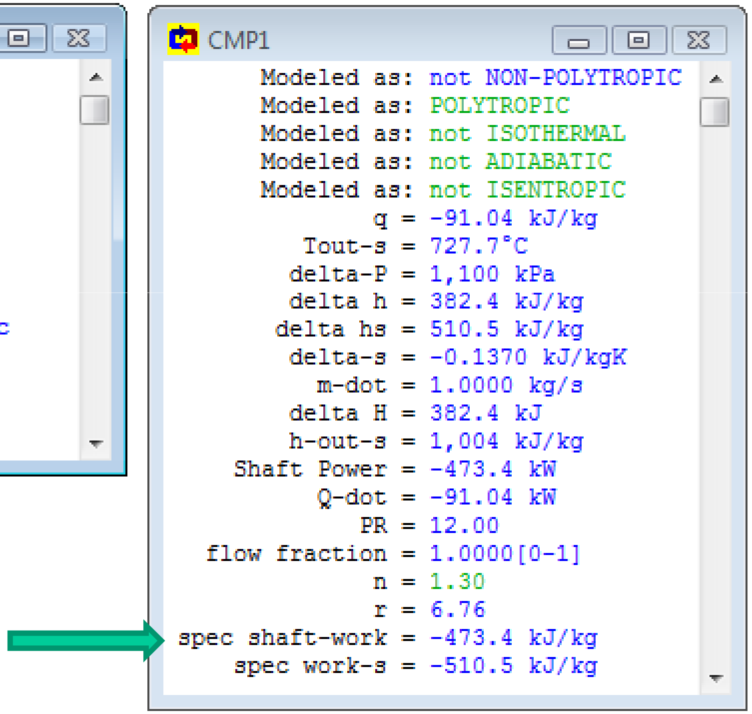


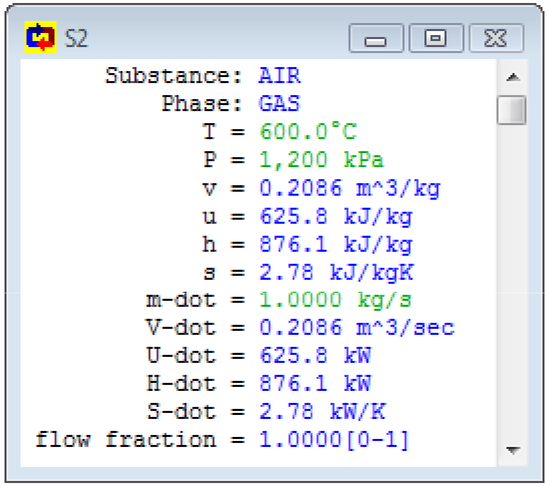
$$\mathbf{w_{12}=\frac{n}{(1-n)}(\,P_2v_2-P_1v_1\,)=n\,w_{12(SC)}} = 1.5\cdot -282 = -423\ \mathrm{kJ/kg}$$

Proceso de compresión reversible en un sistema abierto



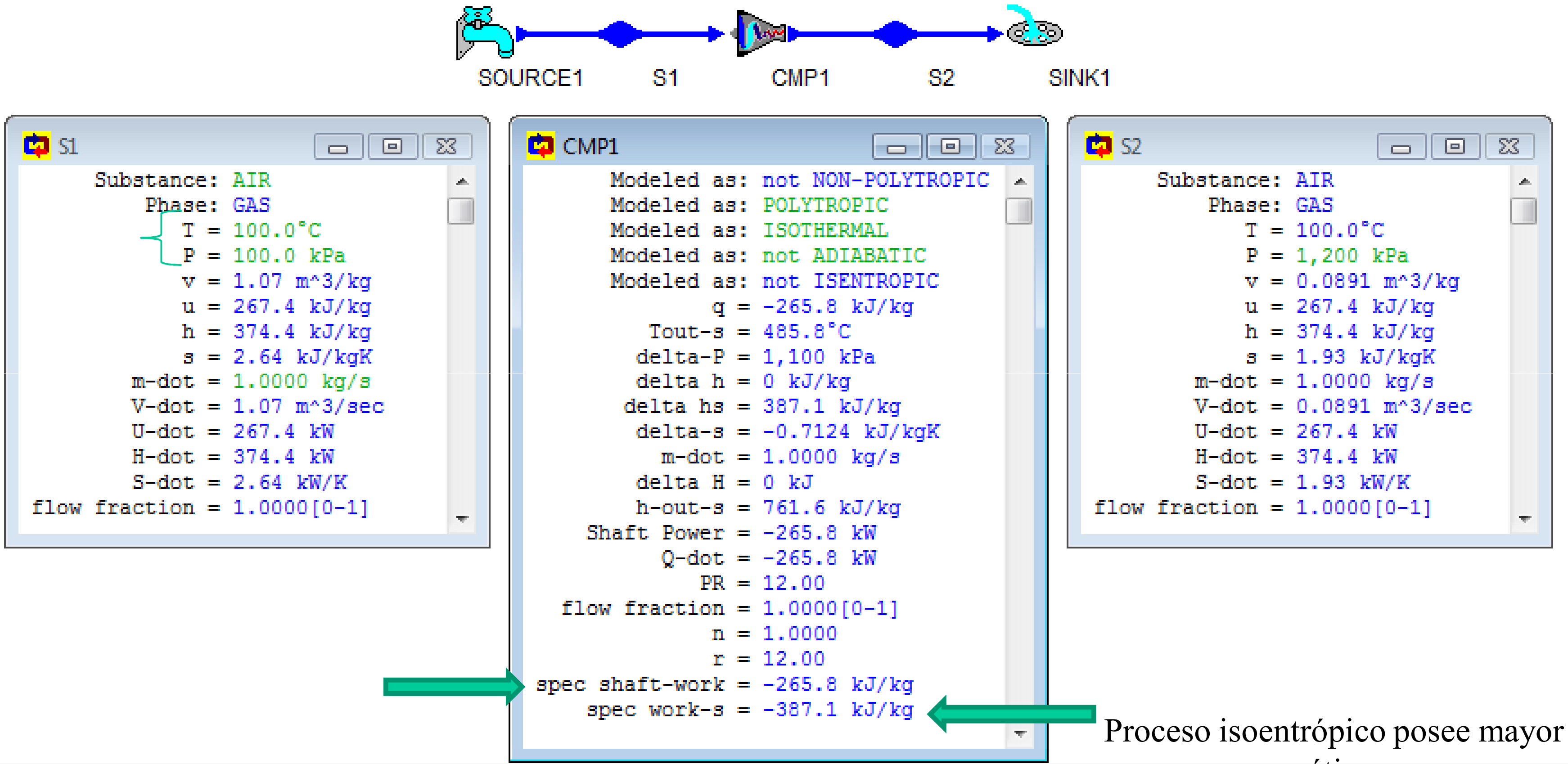






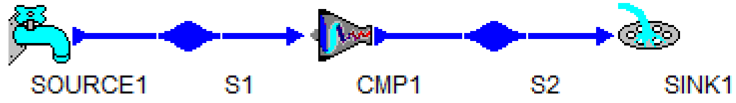
$$w_{12} = \frac{n}{(1-n)}(P_2 v_2 - P_1 v_1) = n\, w_{12(SC)} = 1.3 \cdot -364.2 = -473.4 \text{ kJ/kg}$$

Proceso de compresión reversible en un sistema abierto



Proceso isoentrópico posee mayor consumo energético

Proceso de compresión reversible en un sistema abierto



S1

Substance:	AIR
Phase:	GAS
T =	100.0°C
P =	100.0 kPa
v =	1.07 m^3/kg
u =	267.4 kJ/kg
h =	374.4 kJ/kg
s =	2.64 kJ/kgK
m-dot =	1.0000 kg/s
V-dot =	1.07 m^3/sec
U-dot =	267.4 kW
H-dot =	374.4 kW
S-dot =	2.64 kW/K
flow fraction =	1.0000[0-1]

CMP1

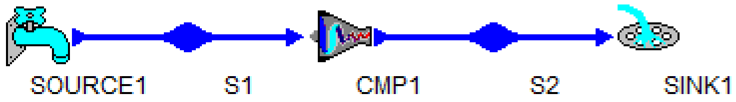
Modeled as:	not NON-POLYTROPIC
Modeled as:	POLYTROPIC
Modeled as:	not ISOTHERMAL
Modeled as:	ADIABATIC
Modeled as:	ISENTROPIC
q =	0 kJ/kg
Tout-s =	485.8°C
delta-P =	1,100 kPa
delta h =	387.1 kJ/kg
delta hs =	387.1 kJ/kg
delta-s =	0 kJ/kgK
m-dot =	1.0000 kg/s
delta H =	387.1 kJ
h-out-s =	761.6 kJ/kg
Shaft Power =	-387.1 kW
Q-dot =	0 kW
PR =	12.00
eta-s =	99.99%
flow fraction =	1.0000[0-1]
n =	1.40
r =	5.90
spec shaft-work =	-387.1 kJ/kg
spec work-s =	-387.1 kJ/kg

S2

Substance:	AIR
Phase:	GAS
T =	485.8°C
P =	1,200 kPa
v =	0.1813 m^3/kg
u =	544.0 kJ/kg
h =	761.6 kJ/kg
s =	2.64 kJ/kgK
m-dot =	1.0000 kg/s
V-dot =	0.1813 m^3/sec
U-dot =	544.0 kW
H-dot =	761.6 kW
S-dot =	2.64 kW/K
flow fraction =	1.0000[0-1]

Verificamos de nuevo que se obtiene mayor trabajo de compresión que el caso isotermo (ver gráfica final)

Proceso de compresión reversible en un sistema abierto



S1

```
    Substance: AIR
        Phase: GAS
            T = 100.0°C
            P = 100.0 kPa
            v = 1.07 m^3/kg
            u = 267.4 kJ/kg
            h = 374.4 kJ/kg
            s = 2.64 kJ/kgK
        m-dot = 1.0000 kg/s
        V-dot = 1.07 m^3/sec
        U-dot = 267.4 kW
        H-dot = 374.4 kW
        S-dot = 2.64 kW/K
flow fraction = 1.0000[0-1]
```

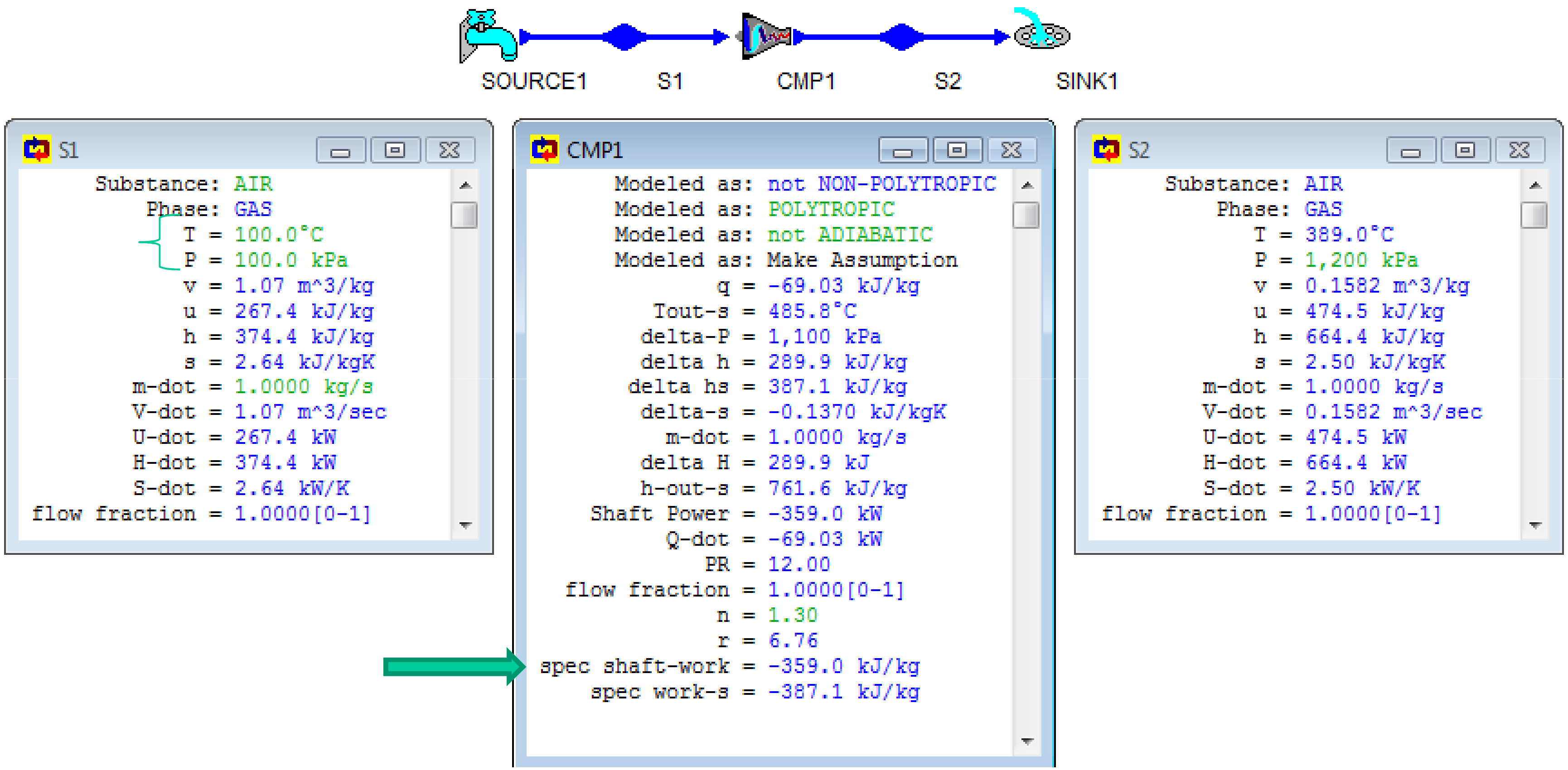
CMP1

```
  Modeled as: not NON-POLYTROPIC
  Modeled as: POLYTROPIC
  Modeled as: not ADIABATIC
  Modeled as: Make Assumption
           q = 68.97 kJ/kg
      Tout-s = 485.8°C
     delta-P = 1,100 kPa
     delta h = 482.8 kJ/kg
    delta hs = 387.1 kJ/kg
     delta-s = 0.1187 kJ/kgK
       m-dot = 1.0000 kg/s
     delta H = 482.8 kJ
     h-out-s = 761.6 kJ/kg
 Shaft Power = -413.8 kW
       Q-dot = 68.97 kW
          PR = 12.00
flow fraction = 1.0000[0-1]
           n = 1.50
           r = 5.24
spec shaft-work = -413.8 kJ/kg
   spec work-s = -387.1 kJ/kg
```

S2

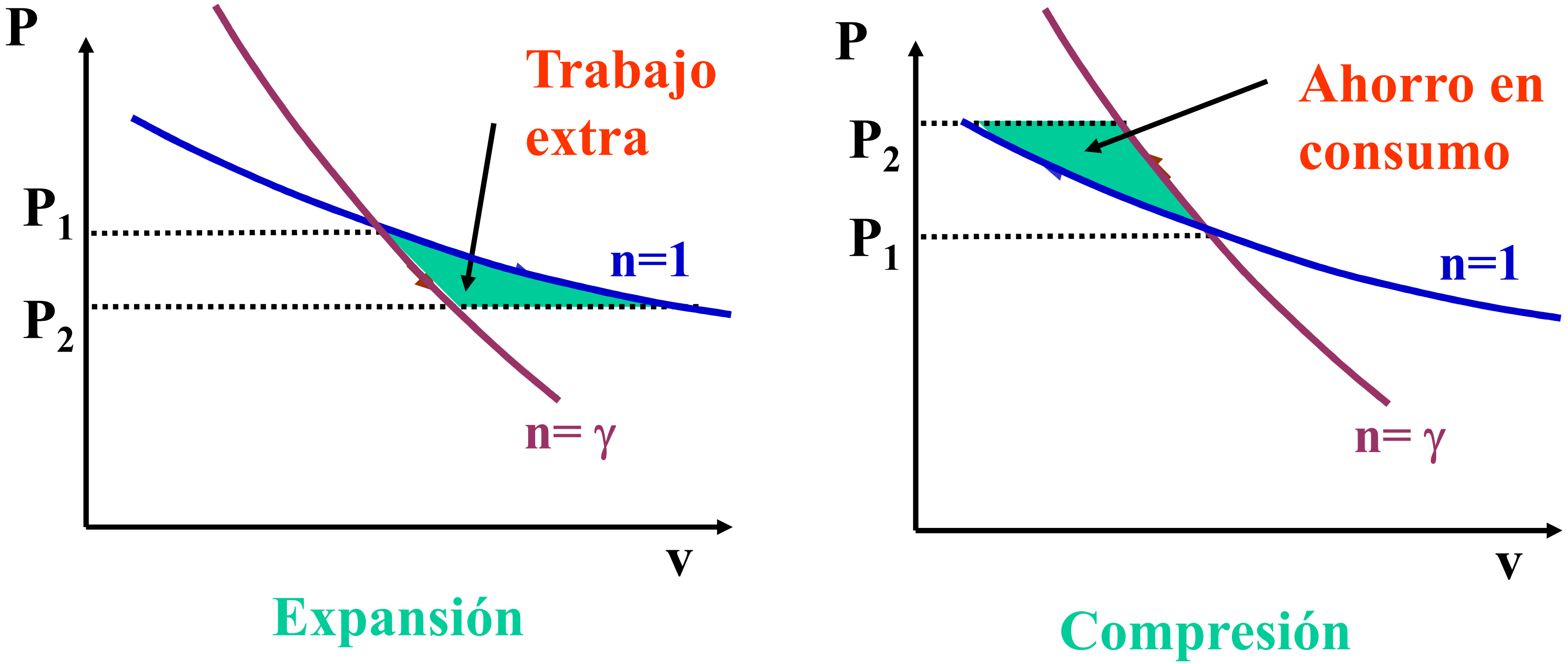
```
    Substance: AIR
        Phase: GAS
            T = 581.2°C
            P = 1,200 kPa
            v = 0.2041 m^3/kg
            u = 612.3 kJ/kg
            h = 857.2 kJ/kg
            s = 2.76 kJ/kgK
        m-dot = 1.0000 kg/s
        V-dot = 0.2041 m^3/sec
        U-dot = 612.3 kW
        H-dot = 857.2 kW
        S-dot = 2.76 kW/K
flow fraction = 1.0000[0-1]
```

Proceso de compresión reversible en un sistema abierto



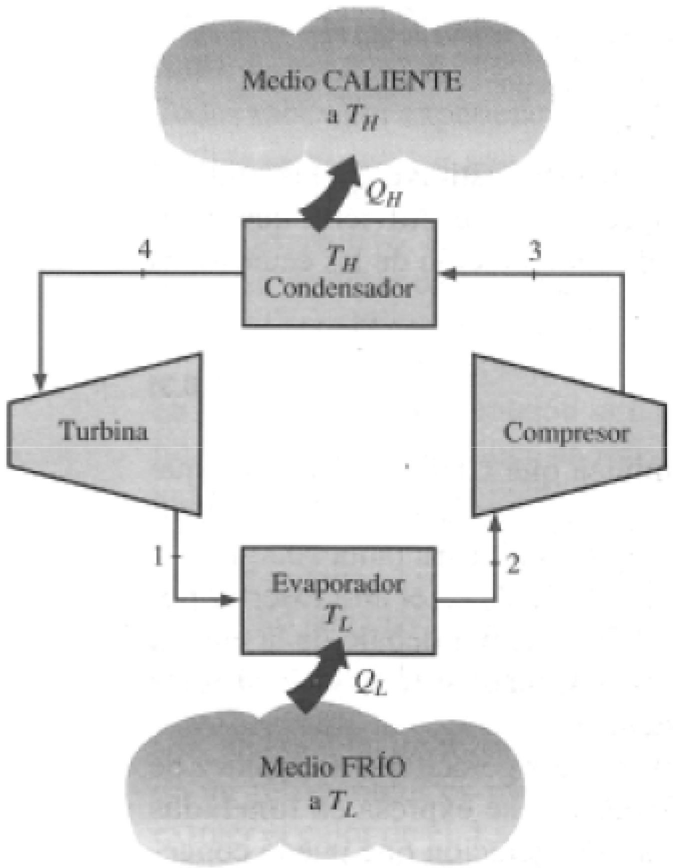
Comparación: Trabajo de expansión y compresión

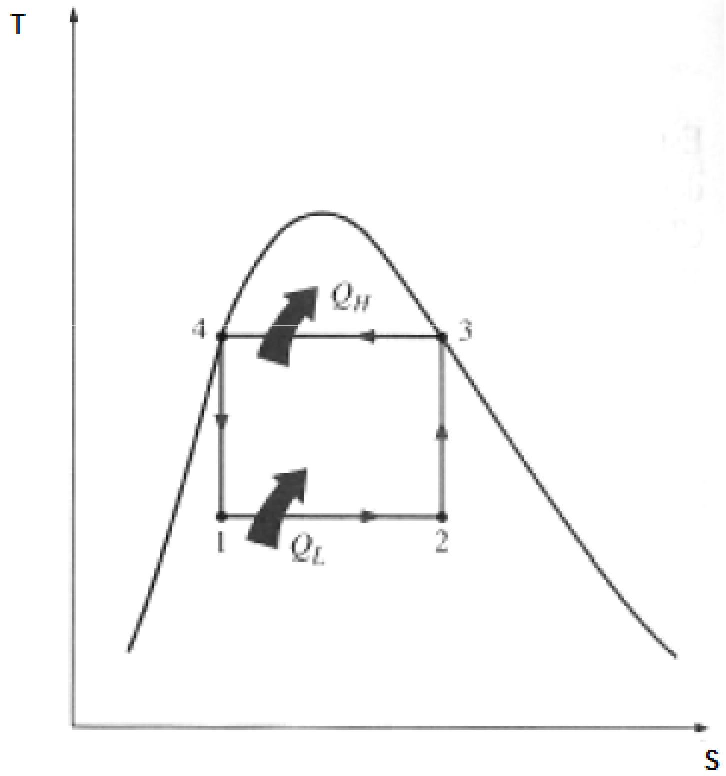
Procesos politrópicos $\Rightarrow$ $$w_{12} = \frac{n}{1-n}\,(P_2 v_2 - P_1 v_1)$$



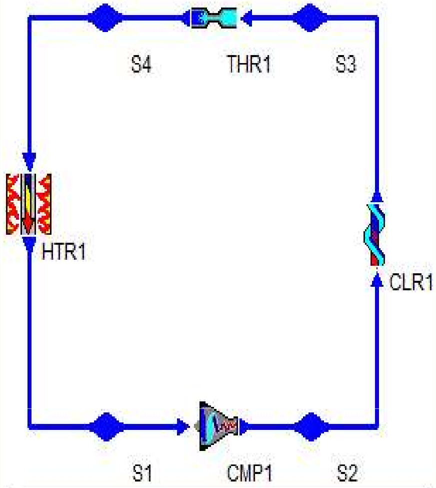
Interesa que ambos procesos se hagan sin variación de Tª, esto en la práctica es verdaderamente complicado

Ciclo de refrigeración por compresión de vapor





Ciclo de refrigeración por compresión de vapor



S1

```
Substance: REFRIGERANT-12
Phase: SATURATED
quality = 1.0000[0-1]
T = 20.64°F
P = 250.0 kPa
v = 0.0680 m^3/kg
u = 167.9 kJ/kg
h = 184.8 kJ/kg
s = 0.6998 kJ/kgK
m-dot = 0.0142 kg/s
T-sat = 20.64°F
P-sat = 250.0 kPa
v-f(Tsat) = 0 m^3/kg
v-g(Tsat) = 0.0680 m^3/kg
u-f(Tsat) = 30.08 kJ/kg
u-g(Tsat) = 167.9 kJ/kg
h-f(Tsat) = 30.25 kJ/kg
h-g(Tsat) = 184.8 kJ/kg
s-f(Tsat) = 0.1206 kJ/kgK
s-g(Tsat) = 0.6998 kJ/kgK
V-dot = 0 m^3/sec
U-dot = 2.39 kW
H-dot = 2.63 kW
S-dot = 0.0099 kW/K
flow fraction = 1.0000[0-1]
```

S4

```
Substance: REFRIGERANT-12
Phase: SATURATED
quality = 0.3611[0-1]
T = 20.64°F
P = 250.0 kPa
v = 0.0250 m^3/kg
u = 79.84 kJ/kg
h = 86.06 kJ/kg
s = 0.3298 kJ/kgK
m-dot = 0.0142 kg/s
T-sat = 20.64°F
P-sat = 250.0 kPa
v-f(Tsat) = 0 m^3/kg
v-g(Tsat) = 0.0680 m^3/kg
u-f(Tsat) = 30.08 kJ/kg
u-g(Tsat) = 167.9 kJ/kg
h-f(Tsat) = 30.25 kJ/kg
h-g(Tsat) = 184.8 kJ/kg
s-f(Tsat) = 0.1206 kJ/kgK
s-g(Tsat) = 0.6998 kJ/kgK
V-dot = 0 m^3/sec
U-dot = 1.14 kW
H-dot = 1.23 kW
S-dot = 0.0047 kW/K
flow fraction = 1.0000[0-1]
```

S3

```
Substance: REFRIGERANT-12
Phase: SATURATED
quality = 0[0-1]
T = 123.9°F
P = 1,250 kPa
v = 0 m^3/kg
u = 85.03 kJ/kg
h = 86.06 kJ/kg
s = 0.3071 kJ/kgK
m-dot = 0.0142 kg/s
T-sat = 123.9°F
P-sat = 1,250 kPa
v-f(Tsat) = 0 m^3/kg
v-g(Tsat) = 0.0138 m^3/kg
u-f(Tsat) = 85.03 kJ/kg
u-g(Tsat) = 189.5 kJ/kg
h-f(Tsat) = 86.06 kJ/kg
h-g(Tsat) = 206.8 kJ/kg
s-f(Tsat) = 0.3071 kJ/kgK
s-g(Tsat) = 0.6794 kJ/kgK
V-dot = 0 m^3/sec
U-dot = 1.21 kW
H-dot = 1.23 kW
S-dot = 0.0044 kW/K
flow fraction = 1.0000[0-1]
```

S2

```
Substance: REFRIGERANT-12
Phase: GAS
T = 138.9°F
P = 1,250 kPa
v = 0.0147 m^3/kg
u = 195.2 kJ/kg
h = 213.5 kJ/kg
s = 0.6998 kJ/kgK
m-dot = 0.0142 kg/s
T-sat = 123.9°F
P-sat = 1,506 kPa
v-f(Tsat) = 0 m^3/kg
v-g(Tsat) = 0.0138 m^3/kg
u-f(Tsat) = 85.03 kJ/kg
u-g(Tsat) = 189.5 kJ/kg
h-f(Tsat) = 86.06 kJ/kg
h-g(Tsat) = 206.8 kJ/kg
s-f(Tsat) = 0.3071 kJ/kgK
s-g(Tsat) = 0.6794 kJ/kgK
V-dot = 0 m^3/sec
U-dot = 2.78 kW
H-dot = 3.04 kW
S-dot = 0.0099 kW/K
flow fraction = 1.0000[0-1]
```

HTR1

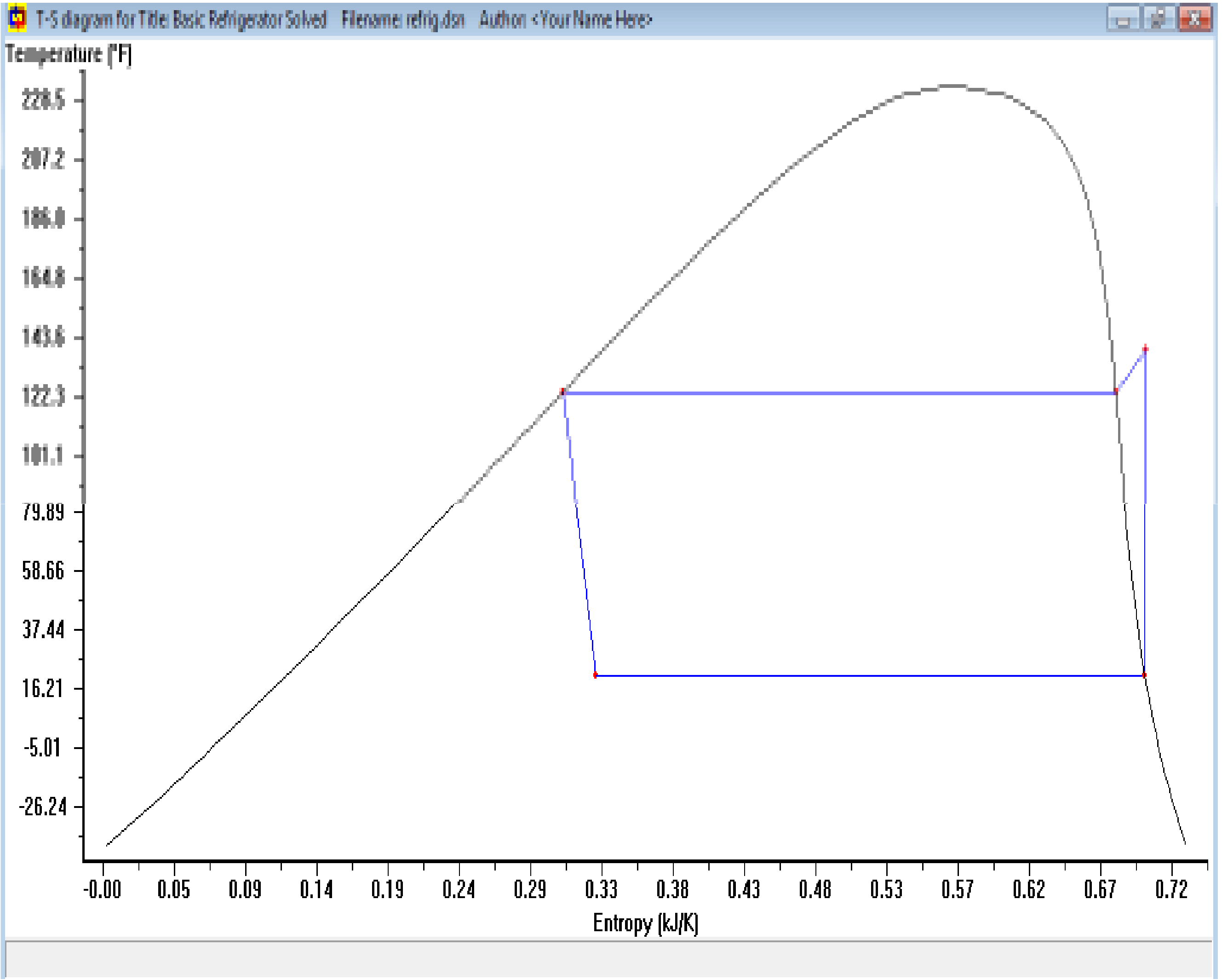
```
Modeled as: not ISOCHORIC
Modeled as: ISOBARIC
q = 98.74 kJ/kg
delta-P = 0 kPa
delta h = 98.74 kJ/kg
delta-s = 0.3700 kJ/kgK
m-dot = 0.0142 kg/s
Q-dot = 1.41 kW
flow fraction = 1.0000[0-1]
```

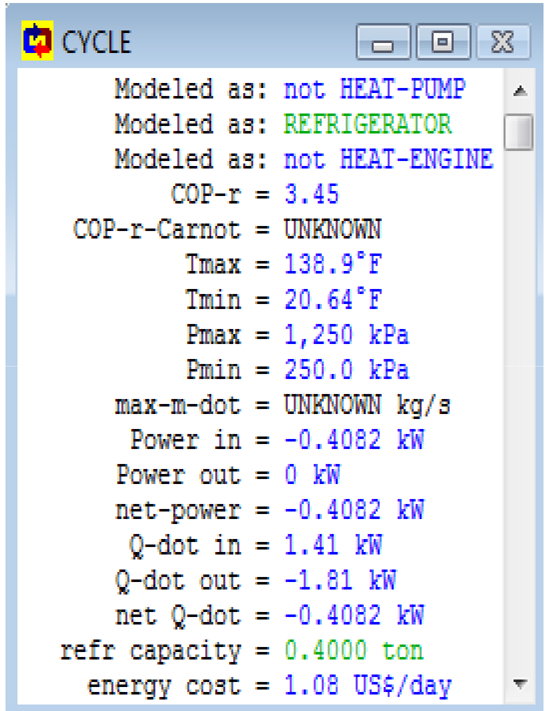
CMP1

```
Modeled as: not ISOTHERMAL
Modeled as: ADIABATIC
Modeled as: ISENTROPIC
Modeled as: Make Assumption
q = 0 kJ/kg
Tout-s = 138.9°F
delta-P = 1000.0 kPa
delta h = 28.65 kJ/kg
delta hs = 28.65 kJ/kg
delta-s = 0 kJ/kgK
m-dot = 0.0142 kg/s
delta H = 0.4082 kJ
h-out-s = 213.5 kJ/kg
Shaft Power = -0.4082 kW
Q-dot = 0 kW
PR = 5.00
eta-s = 100.0%
flow fraction = 1.0000[0-1]
r = 4.63
spec shaft-work = -28.65 kJ/kg
spec work-s = -28.65 kJ/kg
```

CLR1

```
Modeled as: not ISOCHORIC
Modeled as: ISOBARIC
q = -127.4 kJ/kg
delta-P = 0 kPa
delta h = -127.4 kJ/kg
delta-s = -0.3928 kJ/kgK
m-dot = 0.0142 kg/s
Q-dot = -1.81 kW
```


T-S diagram for Title: Basic Refrigerator Solved Filename: refrig.dsn Author <Your Name Here>
Temperature (°F)
228.5
207.2
186.0
164.8
143.6
122.3
101.1
79.89
58.66
37.44
16.21
-5.01
-26.24
-0.00
0.05
0.09
0.14
0.19
0.24
0.29
0.33
0.38
0.43
0.48
0.53
0.57
0.62
0.67
0.72
Entropy (kJ/K)


CYCLE
Modeled as: not HEAT-PUMP
Modeled as: REFRIGERATOR
Modeled as: not HEAT-ENGINE
COP-r = 3.45
COP-r-Carnot = UNKNOWN
Tmax = 138.9°F
Tmin = 20.64°F
Pmax = 1,250 kPa
Pmin = 250.0 kPa
max-m-dot = UNKNOWN kg/s
Power in = -0.4082 kW
Power out = 0 kW
net-power = -0.4082 kW
Q-dot in = 1.41 kW
Q-dot out = -1.81 kW
net Q-dot = -0.4082 kW
refr capacity = 0.4000 ton
energy cost = 1.08 US$/day

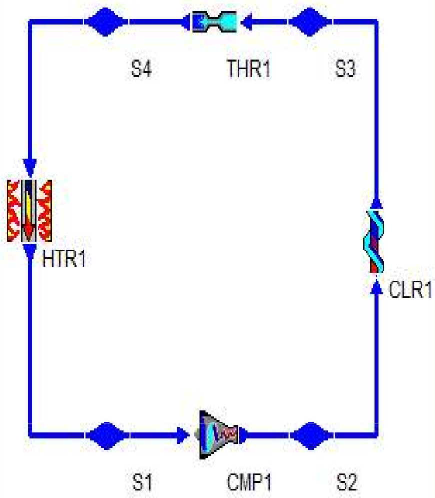
Proceso no isoentrópico en el compresor

S1

Substance:	REFRIGERANT-12
Phase:	SATURATED
quality =	1.0000[0-1]
T =	20.64°F
P =	250.0 kPa
v =	0.0680 m^3/kg
u =	167.9 kJ/kg
h =	184.8 kJ/kg
s =	0.6998 kJ/kgK
m-dot =	0.0142 kg/s
T-sat =	20.64°F
P-sat =	250.0 kPa
v-f(Tsat) =	0 m^3/kg
v-g(Tsat) =	0.0680 m^3/kg
u-f(Tsat) =	30.08 kJ/kg
u-g(Tsat) =	167.9 kJ/kg
h-f(Tsat) =	30.25 kJ/kg
h-g(Tsat) =	184.8 kJ/kg
s-f(Tsat) =	0.1206 kJ/kgK
s-g(Tsat) =	0.6998 kJ/kgK
V-dot =	0 m^3/sec
U-dot =	2.39 kW
H-dot =	2.63 kW
S-dot =	0.0099 kW/K
flow fraction =	1.0000[0-1]

S4

Substance:	REFRIGERANT-12
Phase:	SATURATED
quality =	0.3611[0-1]
T =	20.64°F
P =	250.0 kPa
v =	0.0250 m^3/kg
u =	79.84 kJ/kg
h =	86.06 kJ/kg
s =	0.3298 kJ/kgK
m-dot =	0.0142 kg/s
T-sat =	20.64°F
P-sat =	250.0 kPa
v-f(Tsat) =	0 m^3/kg
v-g(Tsat) =	0.0680 m^3/kg
u-f(Tsat) =	30.08 kJ/kg
u-g(Tsat) =	167.9 kJ/kg
h-f(Tsat) =	30.25 kJ/kg
h-g(Tsat) =	184.8 kJ/kg
s-f(Tsat) =	0.1206 kJ/kgK
s-g(Tsat) =	0.6998 kJ/kgK
V-dot =	0 m^3/sec
U-dot =	1.14 kW
H-dot =	1.23 kW
S-dot =	0.0047 kW/K
flow fraction =	1.0000[0-1]



S3

Substance:	REFRIGERANT-12
Phase:	SATURATED
quality =	0[0-1]
T =	123.9°F
P =	1,250 kPa
v =	0 m^3/kg
u =	85.03 kJ/kg
h =	86.06 kJ/kg
s =	0.3071 kJ/kgK
m-dot =	0.0142 kg/s
T-sat =	123.9°F
P-sat =	1,250 kPa
v-f(Tsat) =	0 m^3/kg
v-g(Tsat) =	0.0138 m^3/kg
u-f(Tsat) =	85.03 kJ/kg
u-g(Tsat) =	189.5 kJ/kg
h-f(Tsat) =	86.06 kJ/kg
h-g(Tsat) =	206.8 kJ/kg
s-f(Tsat) =	0.3071 kJ/kgK
s-g(Tsat) =	0.6794 kJ/kgK
V-dot =	0 m^3/sec
U-dot =	1.21 kW
H-dot =	1.23 kW
S-dot =	0.0044 kW/K
flow fraction =	1.0000[0-1]

S2

Substance:	REFRIGERANT-12
Phase:	GAS
T =	155.0°F
P =	1,250 kPa
v =	0.0155 m^3/kg
u =	201.4 kJ/kg
h =	220.6 kJ/kg
s =	0.7210 kJ/kgK
m-dot =	0.0142 kg/s
T-sat =	123.9°F
P-sat =	1,822 kPa
v-f(Tsat) =	0 m^3/kg
v-g(Tsat) =	0.0138 m^3/kg
u-f(Tsat) =	85.03 kJ/kg
u-g(Tsat) =	189.5 kJ/kg
h-f(Tsat) =	86.06 kJ/kg
h-g(Tsat) =	206.8 kJ/kg
s-f(Tsat) =	0.3071 kJ/kgK
s-g(Tsat) =	0.6794 kJ/kgK
V-dot =	0 m^3/sec
U-dot =	2.87 kW
H-dot =	3.14 kW
S-dot =	0.0103 kW/K
flow fraction =	1.0000[0-1]

HTR1

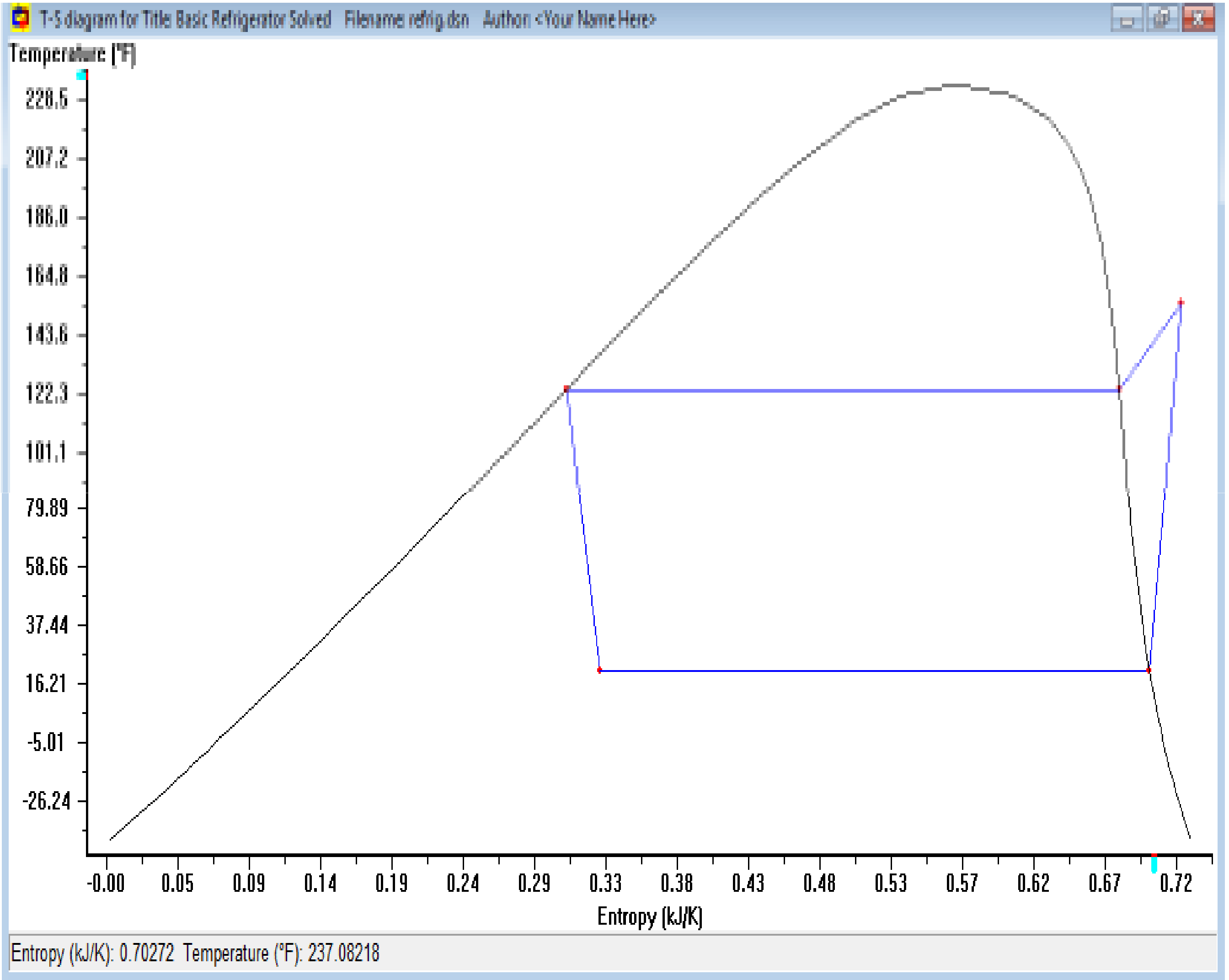
Modeled as:	not ISOCHORIC
Modeled as:	ISOBARIC
q =	98.74 kJ/kg
delta-P =	0 kPa
delta h =	98.74 kJ/kg
delta-s =	0.3700 kJ/kgK
m-dot =	0.0142 kg/s
Q-dot =	1.41 kW
flow fraction =	1.0000[0-1]

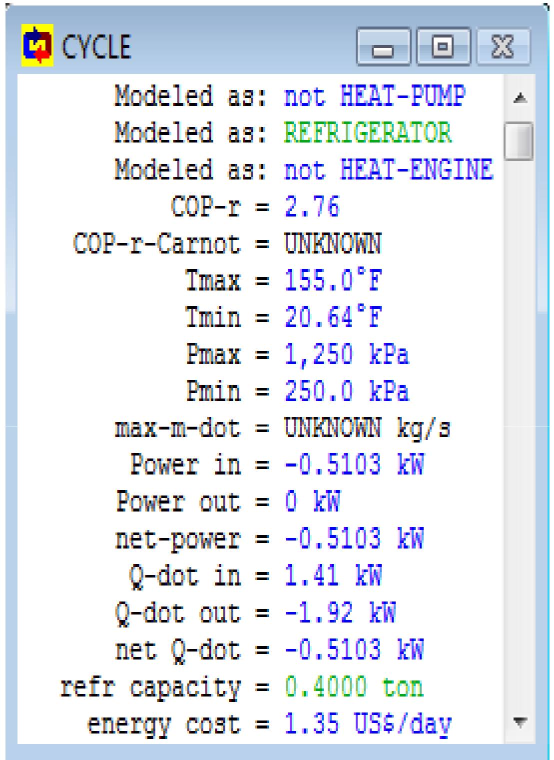
CMP1

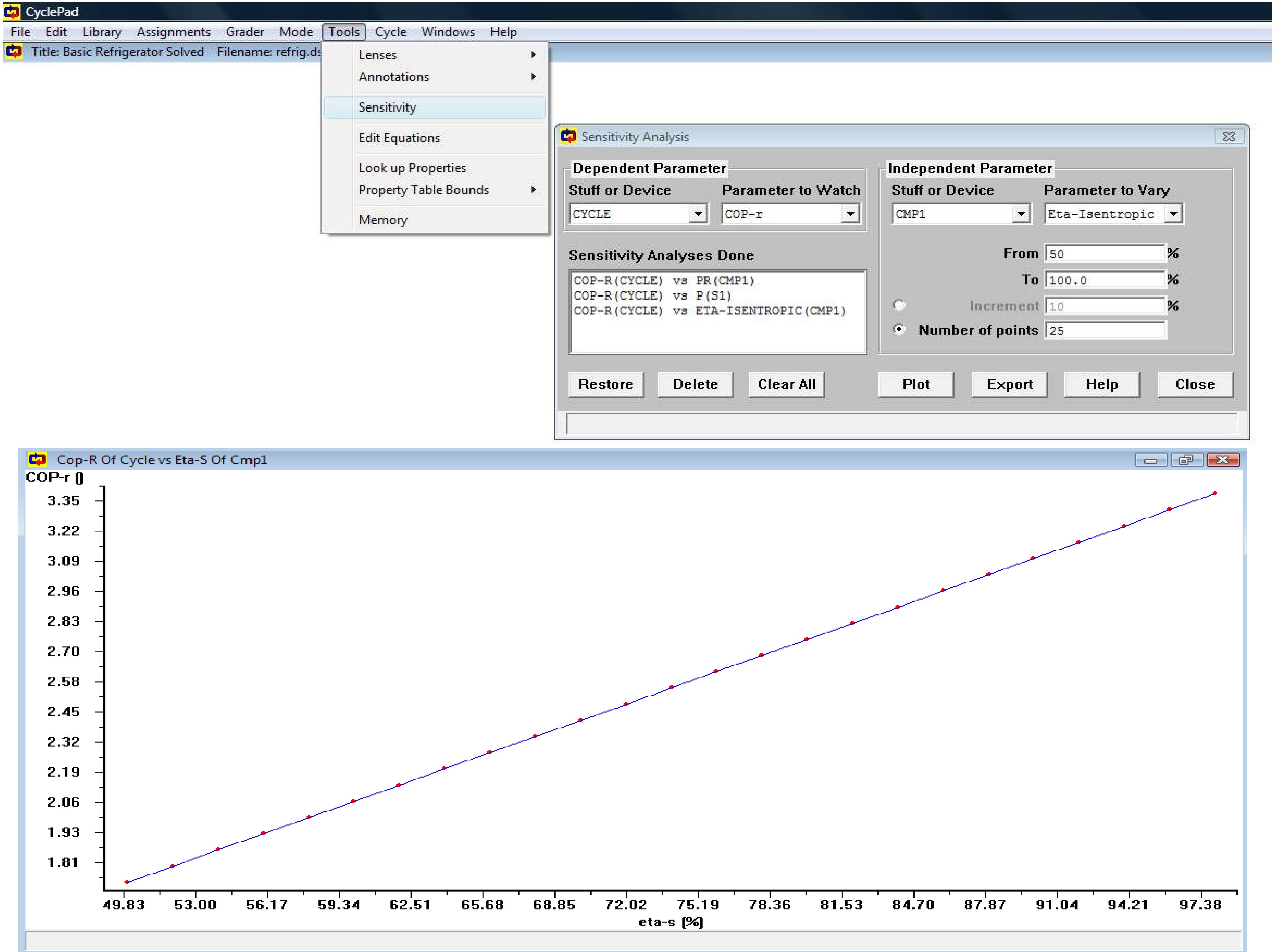
Modeled as:	ADIABATIC
Modeled as:	not ISENTROPIC
Modeled as:	Make Assumption
q =	0 kJ/kg
Tout-s =	138.9°F
delta-P =	1000.0 kPa
delta h =	35.82 kJ/kg
delta hs =	28.65 kJ/kg
delta-s =	0.0212 kJ/kgK
m-dot =	0.0142 kg/s
delta H =	0.5103 kJ
h-out-s =	213.5 kJ/kg
Shaft Power =	-0.5103 kW
Q-dot =	0 kW
PR =	5.00
eta-s =	80.00%
flow fraction =	1.0000[0-1]
r =	4.39
spec shaft-work =	-35.82 kJ/kg
spec work-s =	-28.65 kJ/kg

CLR1

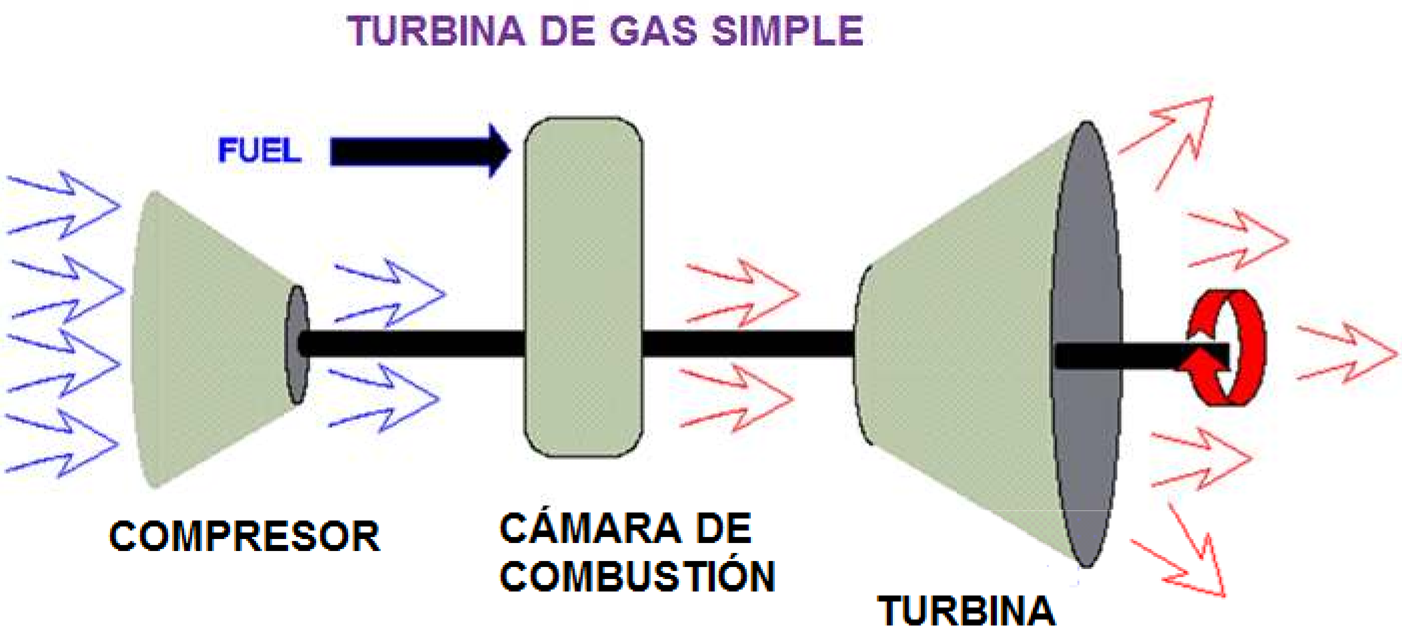
Modeled as:	not ISOCHORIC
Modeled as:	ISOBARIC
q =	-134.6 kJ/kg
delta-P =	0 kPa
delta h =	-134.6 kJ/kg
delta-s =	-0.4140 kJ/kgK
m-dot =	0.0142 kg/s
Q-dot =	-1.92 kW

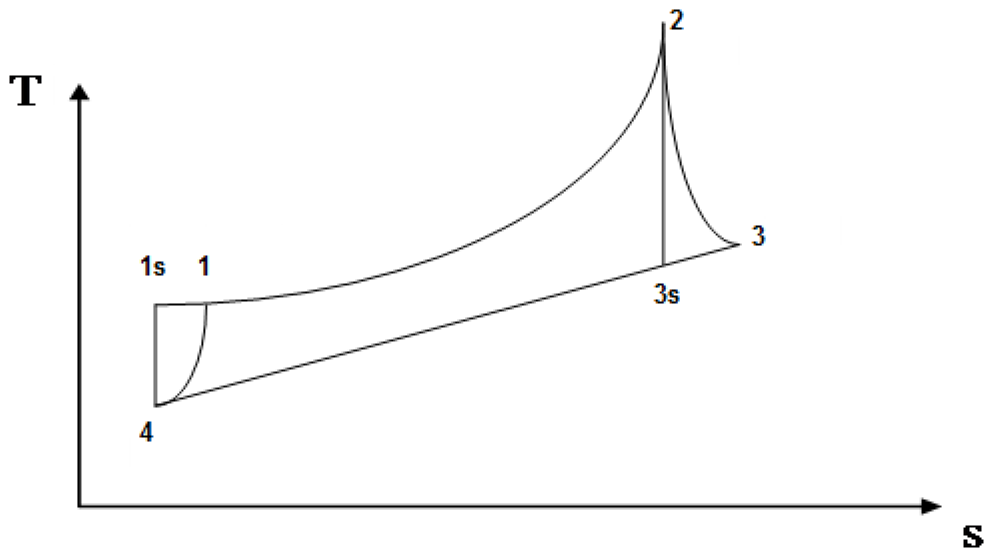

T-S diagram for Title Basic Refrigerator Solved Filename refrig.dsn Author <Your Name Here>
Temperature [°F]
228.5
207.2
186.0
164.8
143.6
122.3
101.1
79.89
58.66
37.44
16.21
-5.01
-26.24
-0.00
0.05
0.09
0.14
0.19
0.24
0.29
0.33
0.38
0.43
0.48
0.53
0.57
0.62
0.67
0.72
Entropy (kJ/K)
Entropy (kJ/K): 0.70272 Temperature (°F): 237.08218


CYCLE
Modeled as: not HEAT-PUMP
Modeled as: REFRIGERATOR
Modeled as: not HEAT-ENGINE
COP-r = 2.76
COP-r-Carnot = UNKNOWN
Tmax = 155.0°F
Tmin = 20.64°F
Pmax = 1,250 kPa
Pmin = 250.0 kPa
max-m-dot = UNKNOWN kg/s
Power in = -0.5103 kW
Power out = 0 kW
net-power = -0.5103 kW
Q-dot in = 1.41 kW
Q-dot out = -1.92 kW
net Q-dot = -0.5103 kW
refr capacity = 0.4000 ton
energy cost = 1.35 US$/day

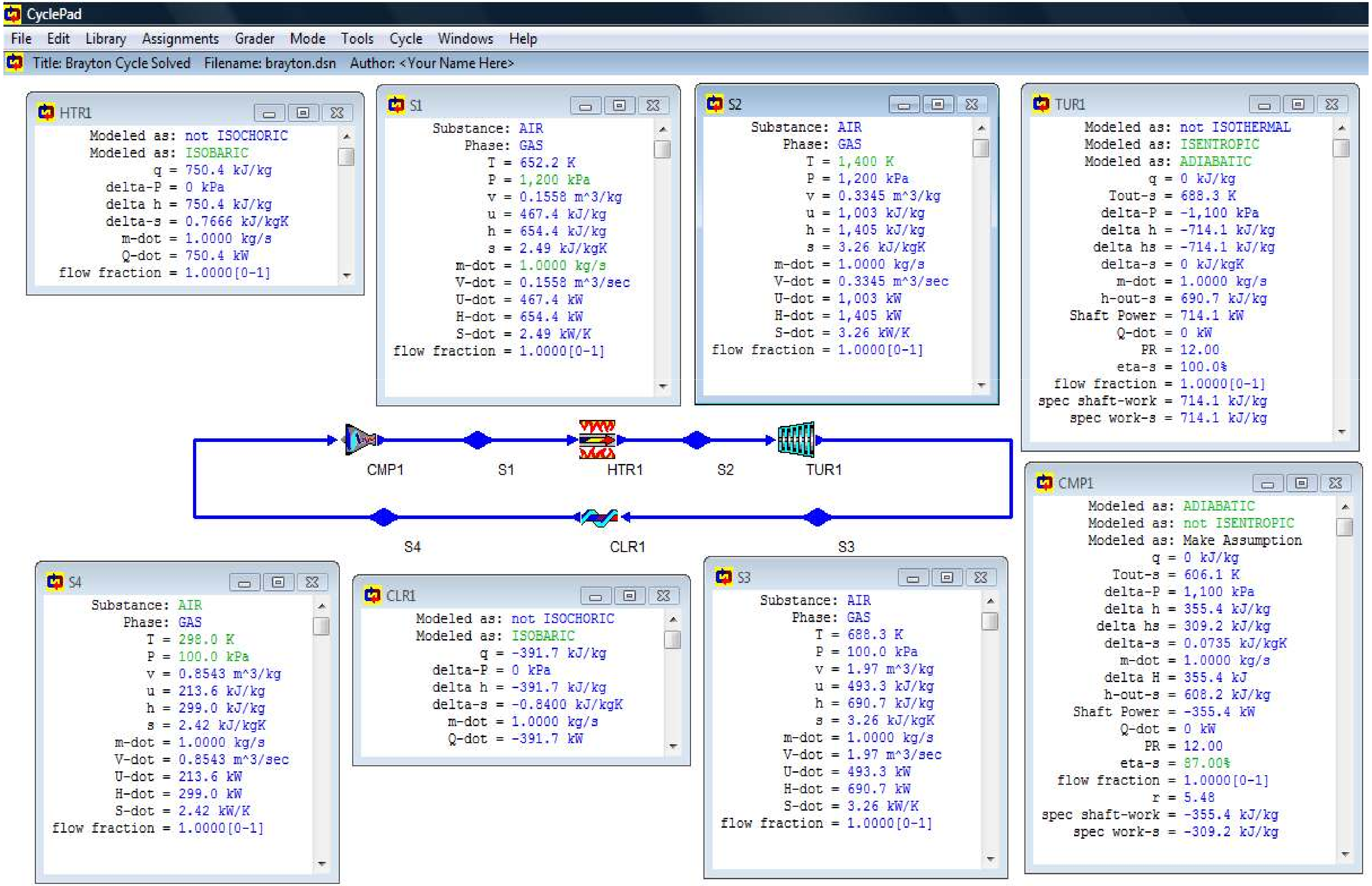

CyclePad
File Edit Library Assignments Grader Mode Tools Cycle Windows Help
Title: Basic Refrigerator Solved Filename: refrig.ds
Lenses
Annotations
Sensitivity
Edit Equations
Look up Properties
Property Table Bounds
Memory
Sensitivity Analysis
Dependent Parameter
Stuff or Device
Parameter to Watch
CYCLE
COP-r
Independent Parameter
Stuff or Device
Parameter to Vary
CMP1
Eta-Isentropic
Sensitivity Analyses Done
COP-R(CYCLE) vs PR(CMP1)
COP-R(CYCLE) vs P(S1)
COP-R(CYCLE) vs ETA-ISENTROPIC(CMP1)
From 50 %
To 100.0 %
Increment 10 %
Number of points 25
Restore
Delete
Clear All
Plot
Export
Help
Close
Cop-R Of Cycle vs Eta-S Of Cmp1
COP-r []
3.35
3.22
3.09
2.96
2.83
2.70
2.58
2.45
2.32
2.19
2.06
1.93
1.81
49.83
53.00
56.17
59.34
62.51
65.68
68.85
72.02
75.19
78.36
81.53
84.70
87.87
91.04
94.21
97.38
eta-s [%]

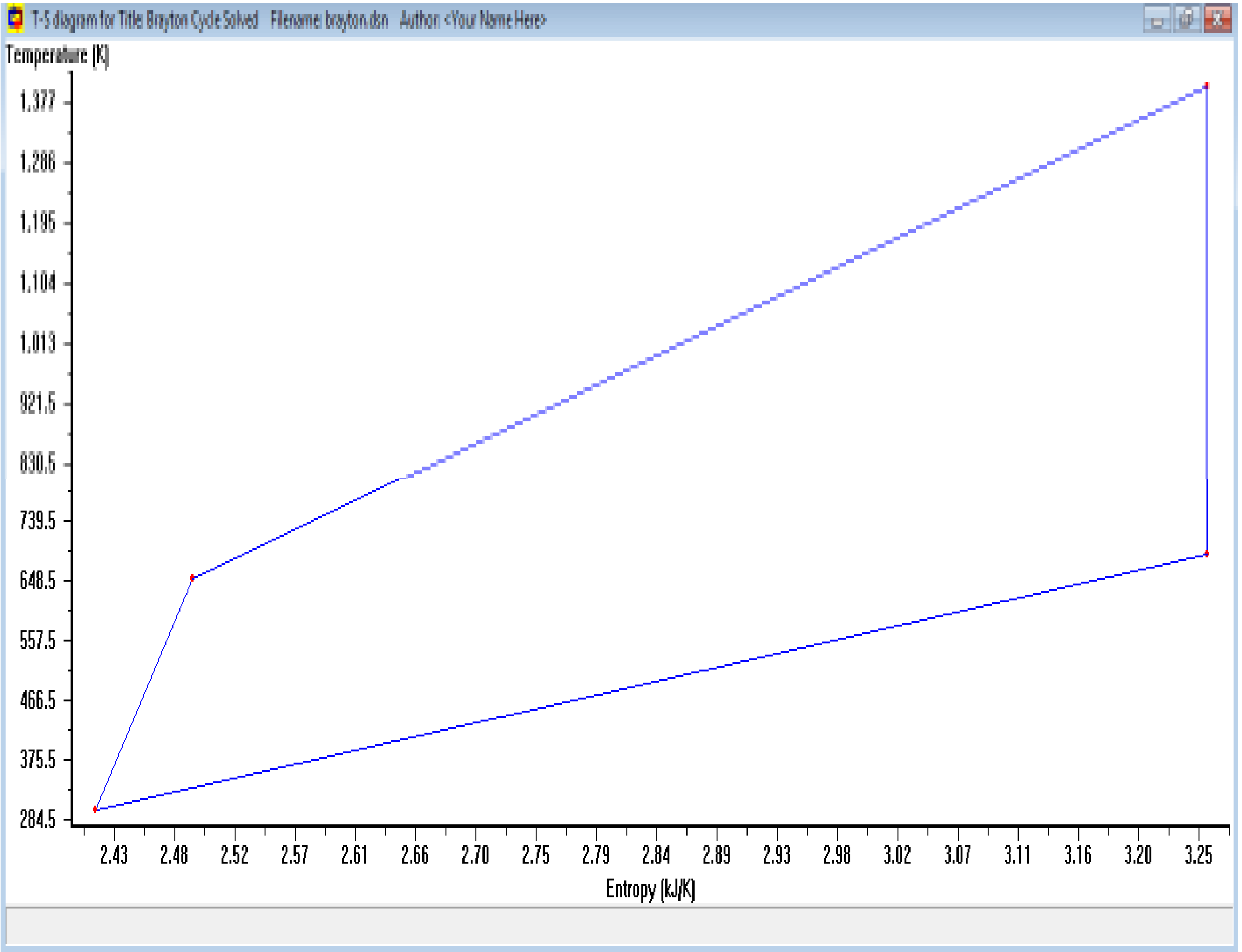
Ciclo de Brayton

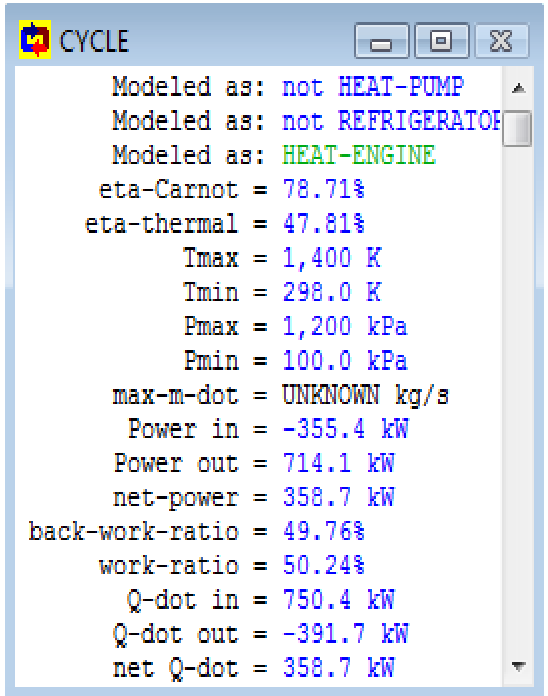




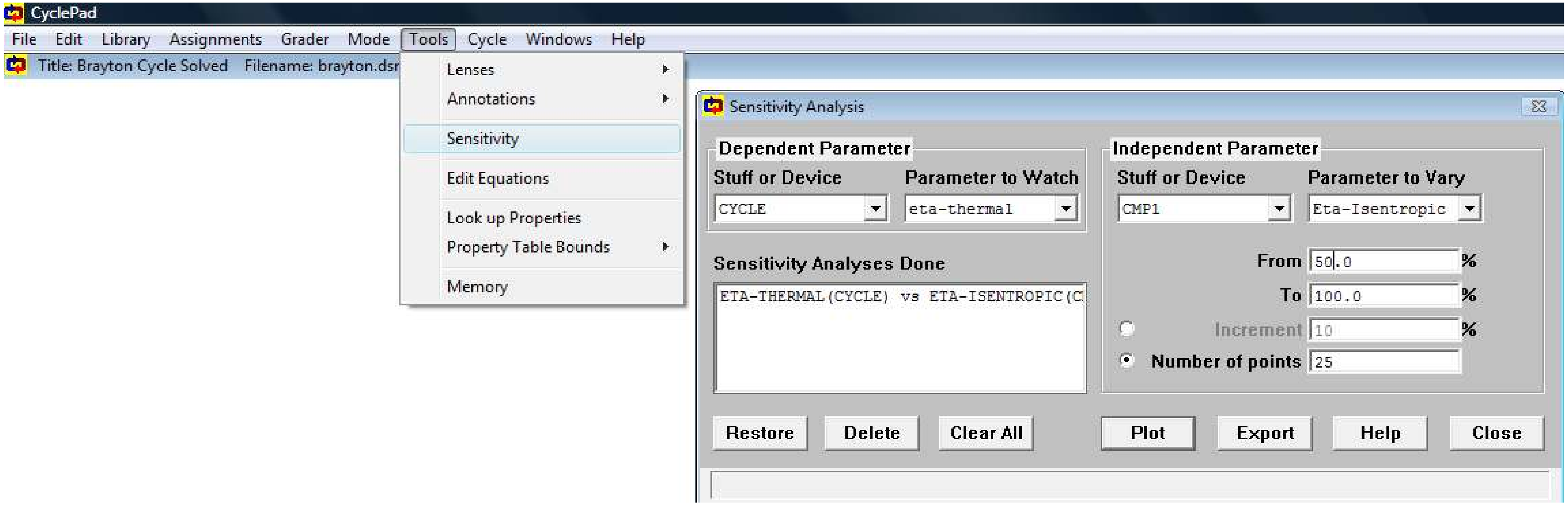
Ciclo de Brayton

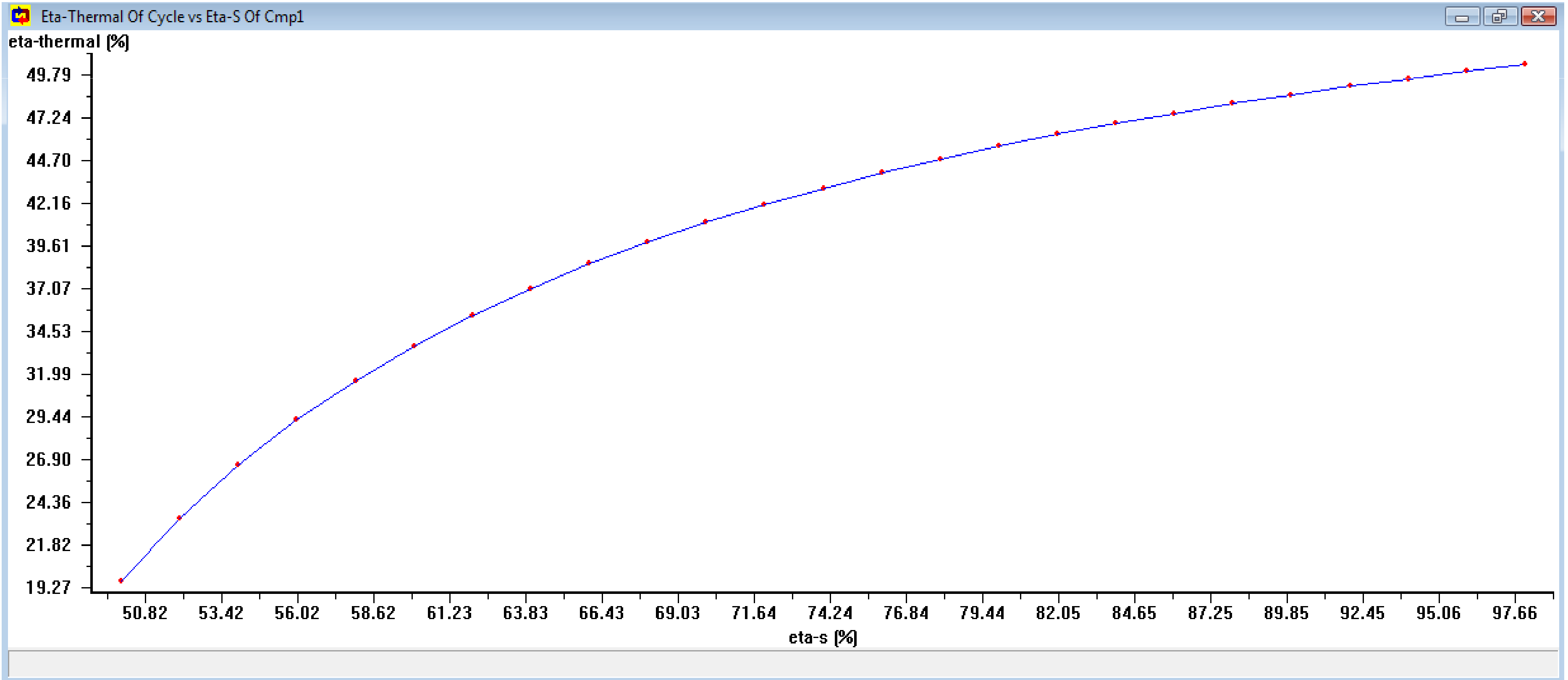





CYCLE

Modeled as: not HEAT-PUMP
Modeled as: not REFRIGERATOR
Modeled as: HEAT-ENGINE
eta-Carnot = 78.71%
eta-thermal = 47.81%
Tmax = 1,400 K
Tmin = 298.0 K
Pmax = 1,200 kPa
Pmin = 100.0 kPa
max-m-dot = UNKNOWN kg/s
Power in = -355.4 kW
Power out = 714.1 kW
net-power = 358.7 kW
back-work-ratio = 49.76%
work-ratio = 50.24%
Q-dot in = 750.4 kW
Q-dot out = -391.7 kW
net Q-dot = 358.7 kW


CyclePad
File Edit Library Assignments Grader Mode Tools Cycle Windows Help
Title: Brayton Cycle Solved Filename: brayton.dsn
Lenses
Annotations
Sensitivity
Edit Equations
Look up Properties
Property Table Bounds
Memory
Sensitivity Analysis
Dependent Parameter
Stuff or Device
Parameter to Watch
CYCLE
eta-thermal
Independent Parameter
Stuff or Device
Parameter to Vary
CMP1
Eta-Isentropic
From 50.0 %
To 100.0 %
Increment 10 %
Number of points 25
Sensitivity Analyses Done
ETA-THERMAL(CYCLE) vs ETA-ISENTROPIC(C
Restore
Delete
Clear All
Plot
Export
Help
Close

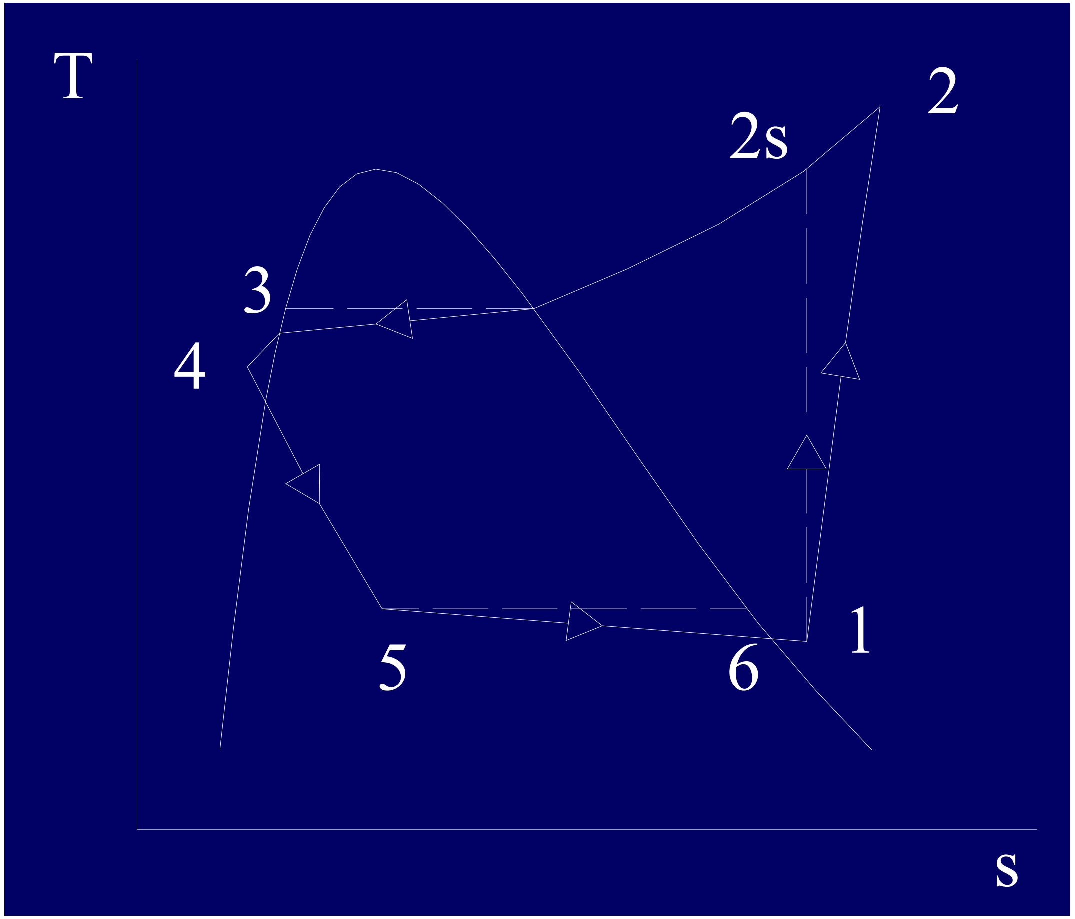

Eta-Thermal Of Cycle vs Eta-S Of Cmp1
eta-thermal (%)
49.79
47.24
44.70
42.16
39.61
37.07
34.53
31.99
29.44
26.90
24.36
21.82
19.27
50.82
53.42
56.02
58.62
61.23
63.83
66.43
69.03
71.64
74.24
76.84
79.44
82.05
84.65
87.25
89.85
92.45
95.06
97.66
eta-s (%)

Problemas a resolver:

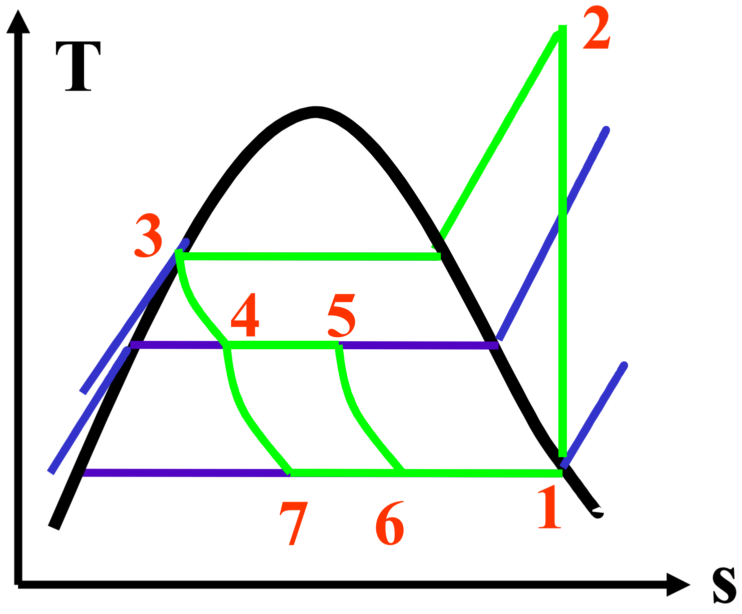
- Grupos de dos alumnos

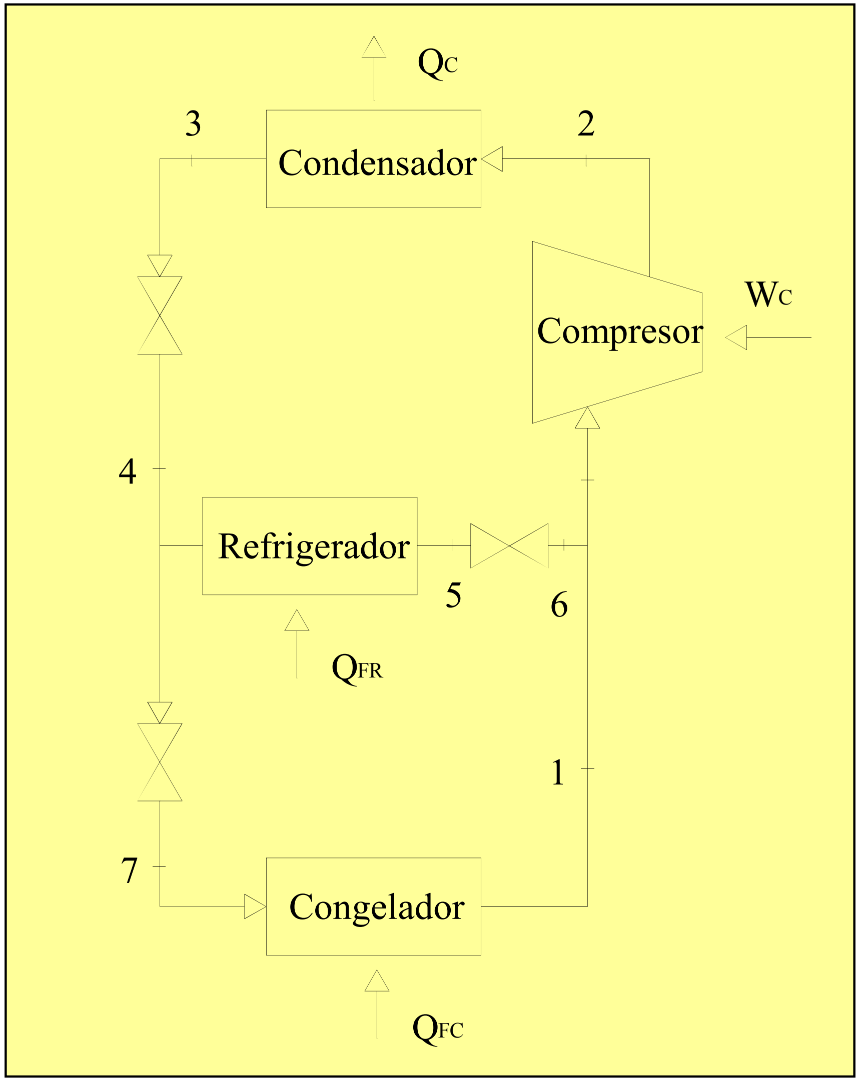
- Elegir uno de los siguientes problemas:

Ciclo de refrigeración real

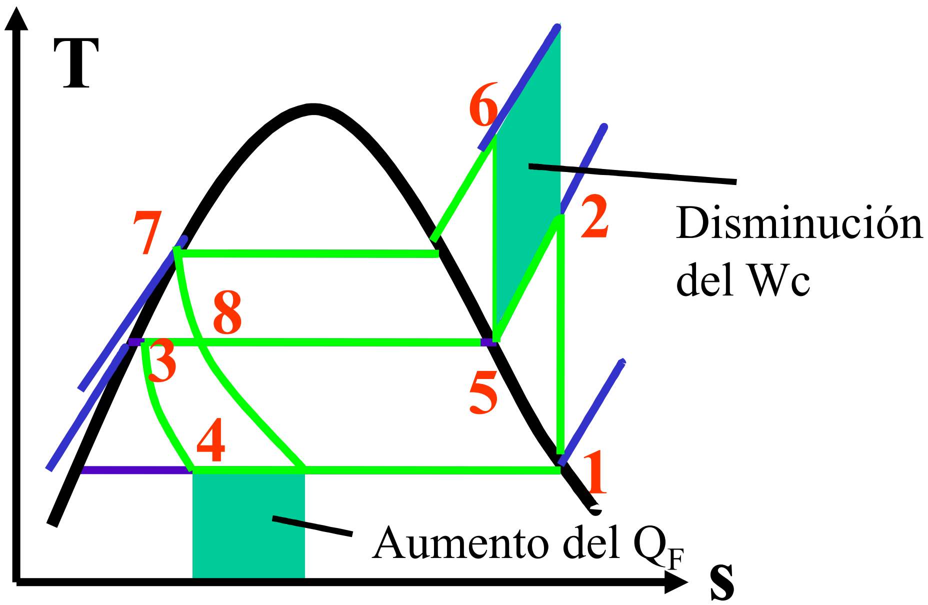


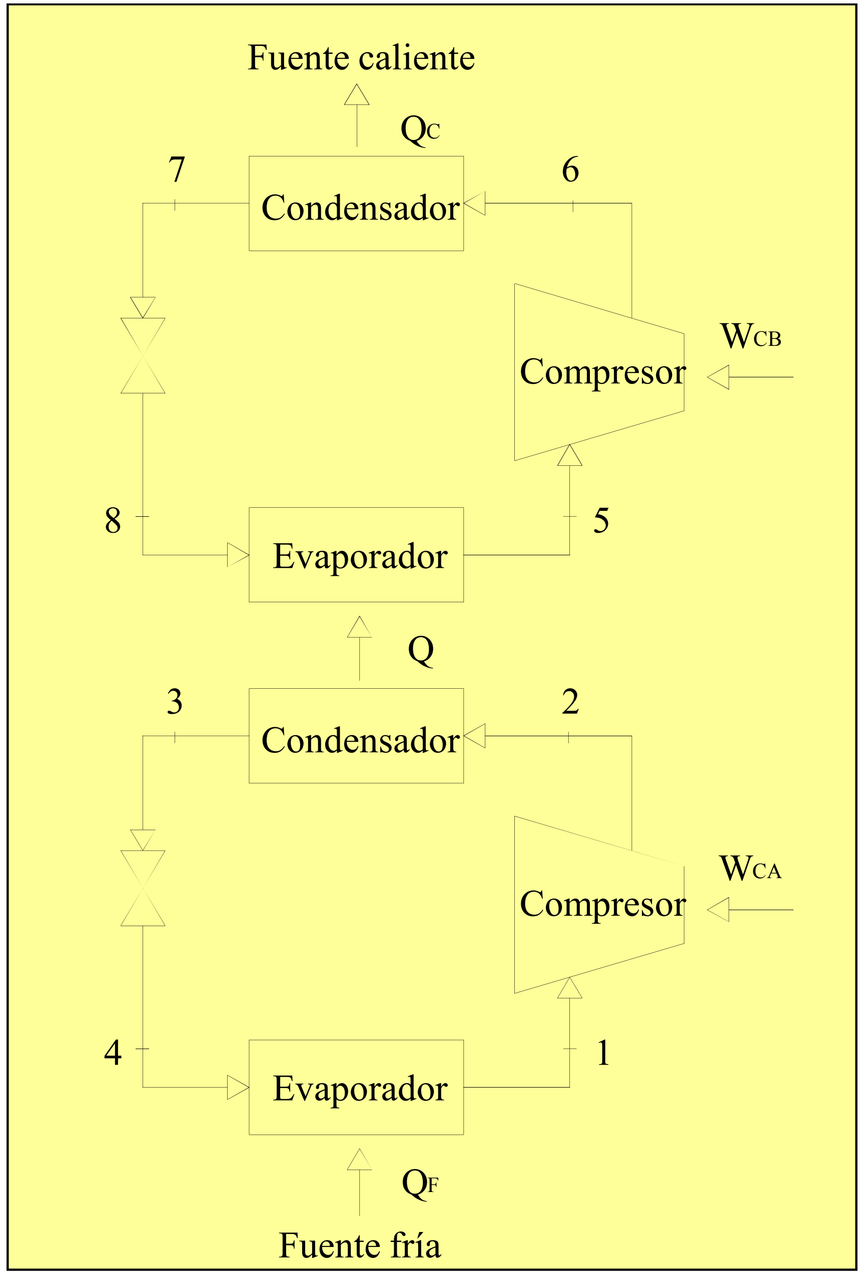
SISTEMAS DE REFRIGERACIÓN DE PROPÓSITO MÚLTIPLE CON UN COMPRESOR



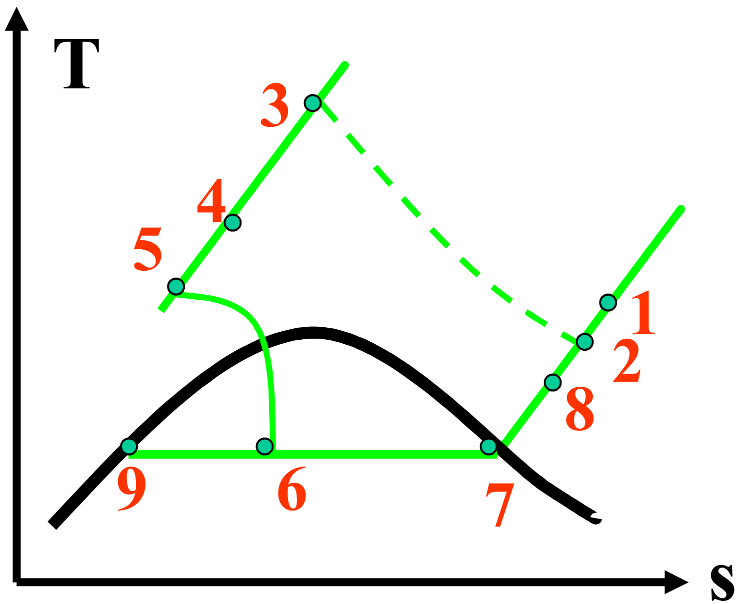


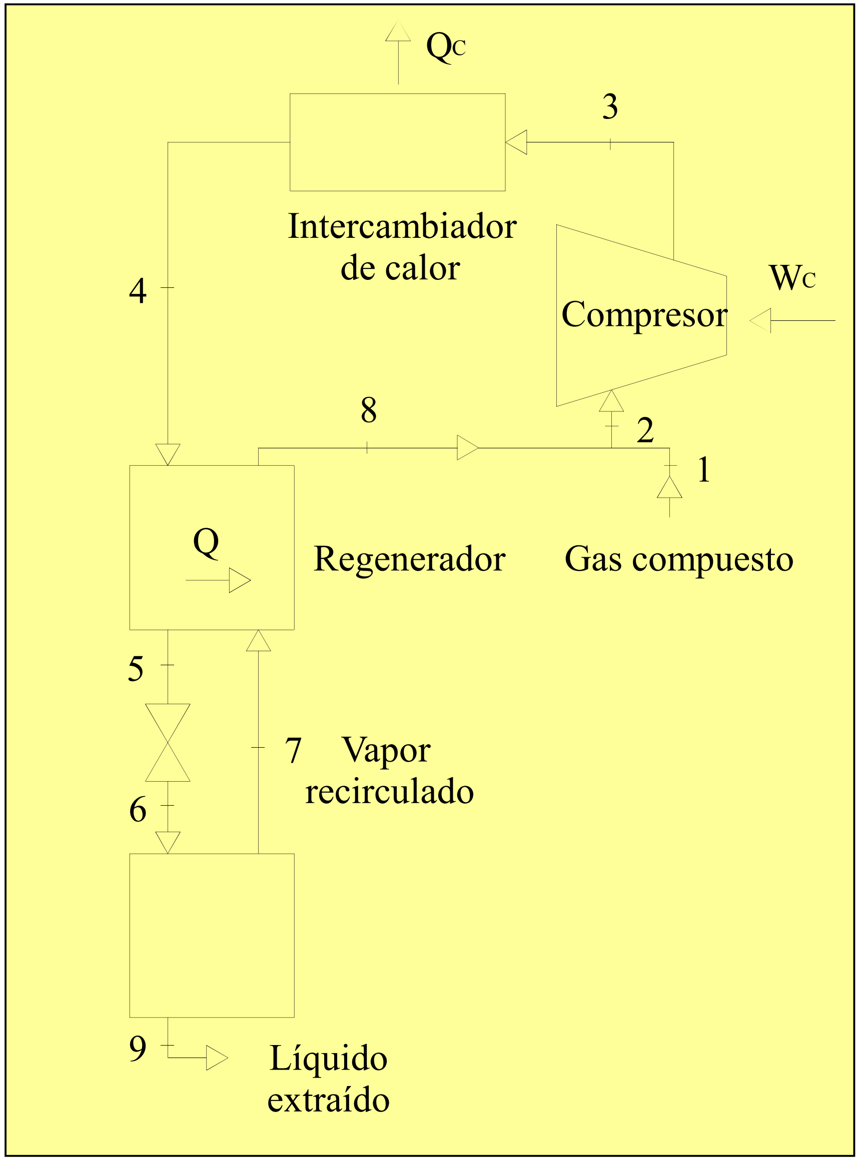
SISTEMAS DE REFRIGERACIÓN EN CASCADA



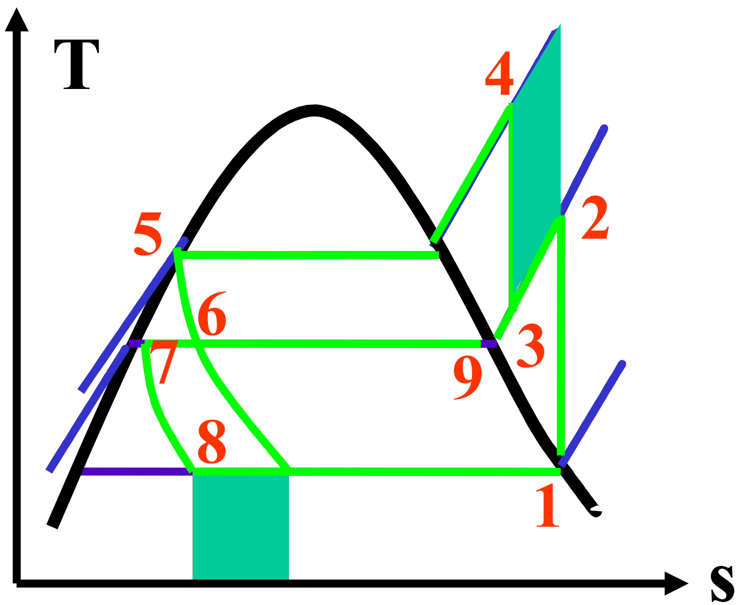


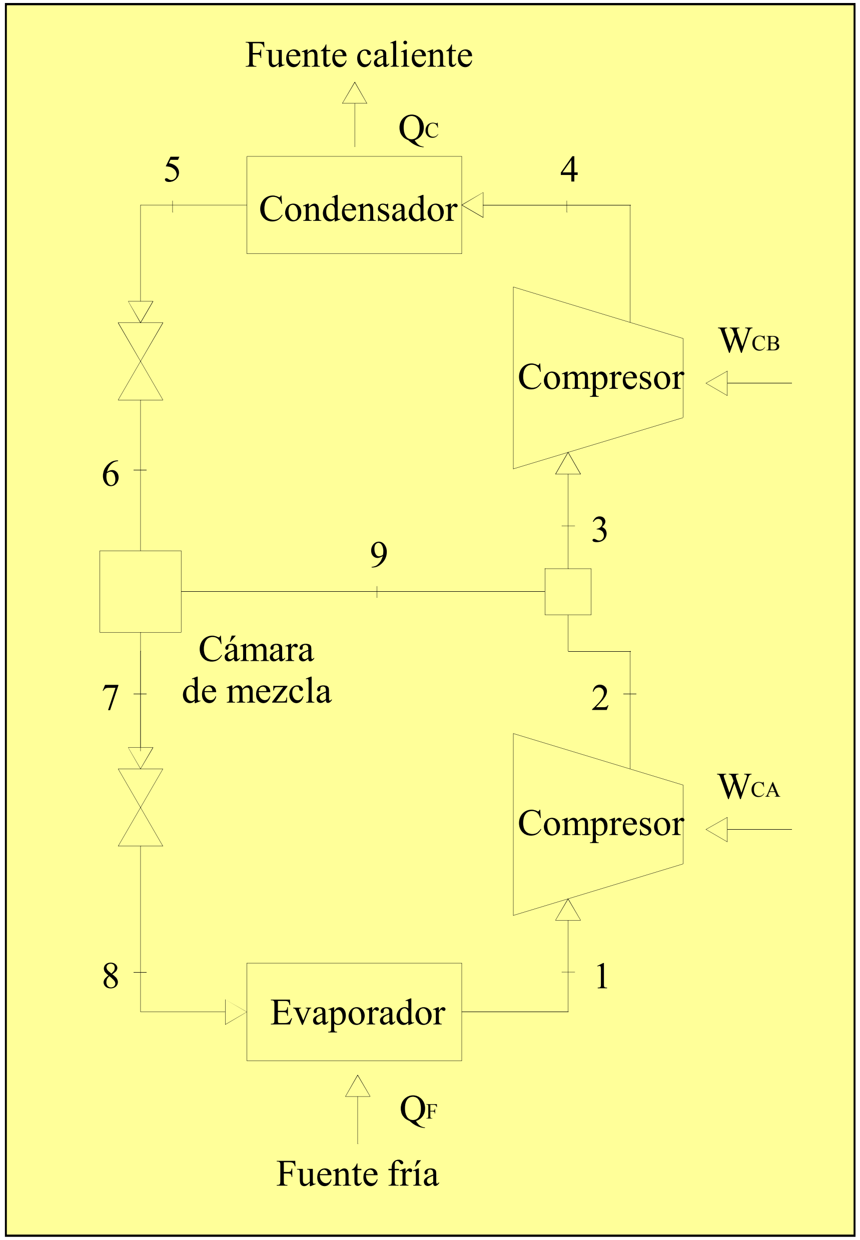
SISTEMAS DE REFRIGERACIÓN PARA LICUEFACCIÓN DE GASES



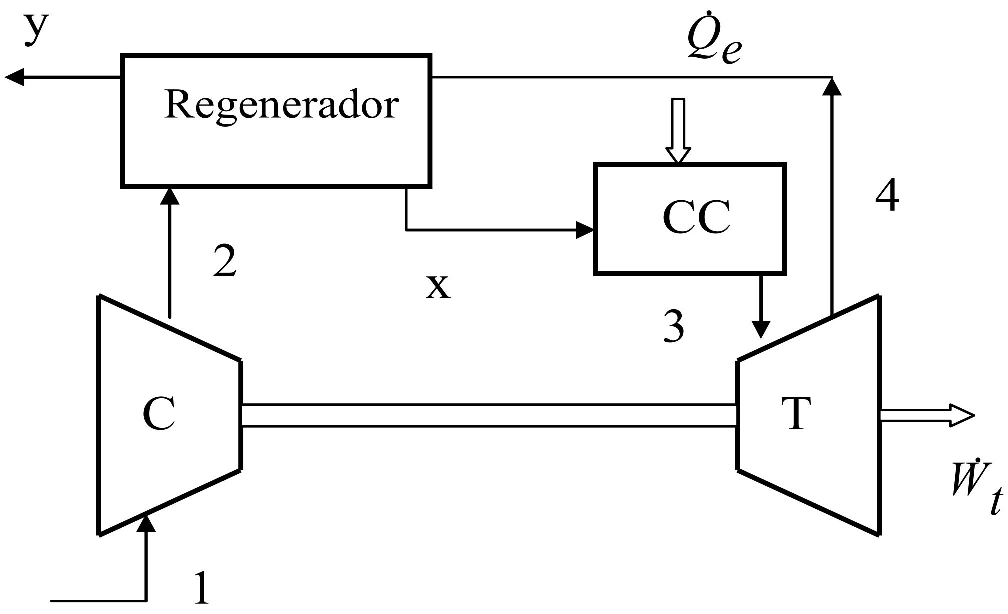


SISTEMAS DE REFRIGERACIÓN MULTIETAPA

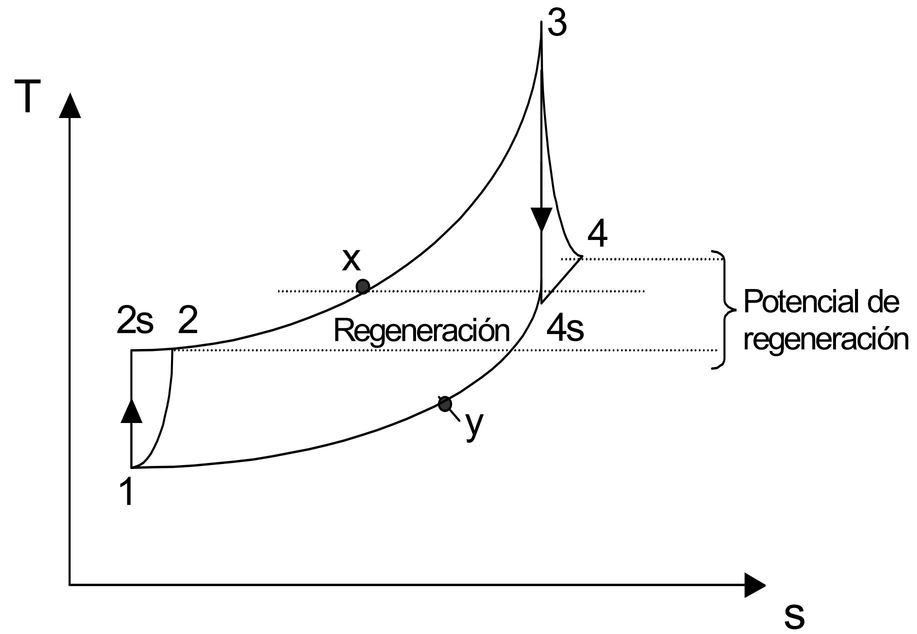




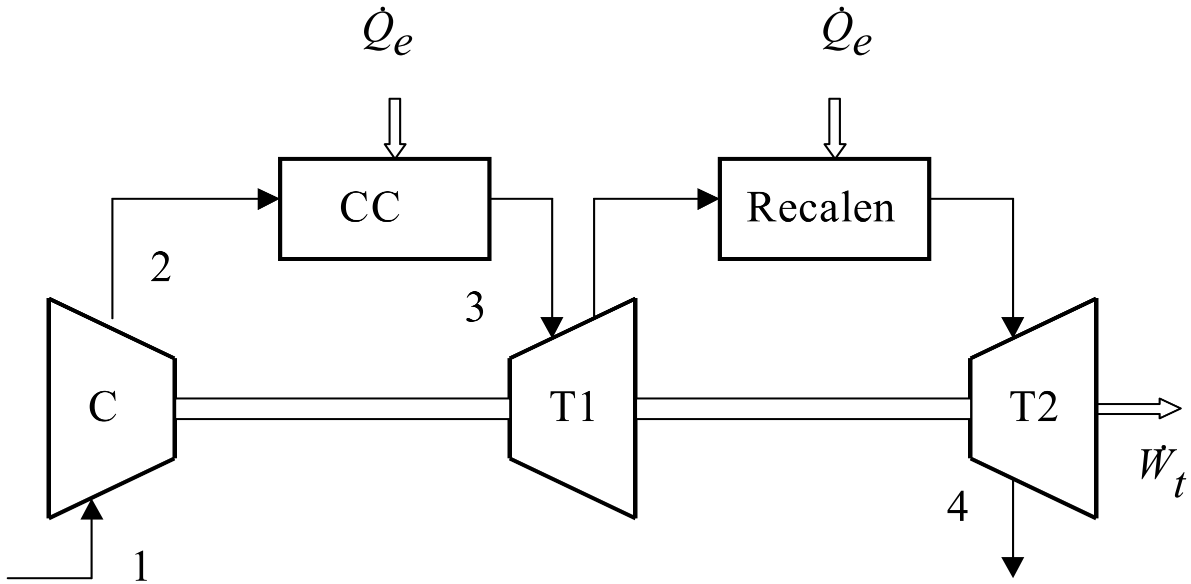
Esquema de la instalación regenerativa

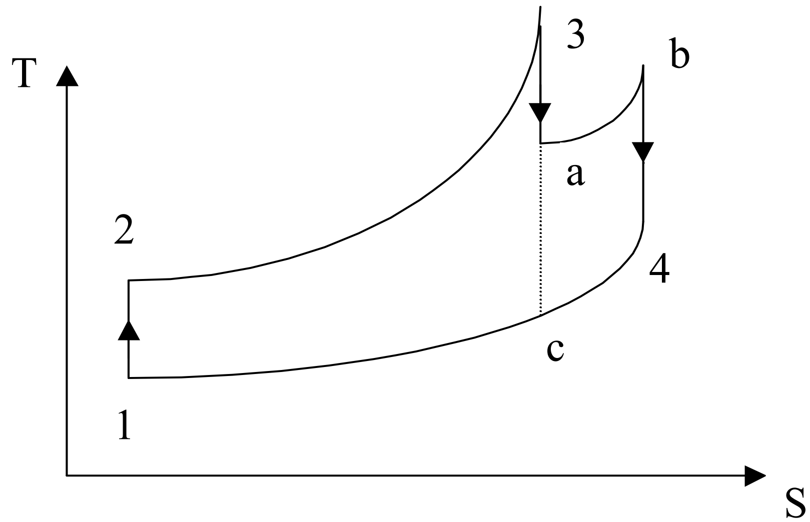


$$\eta_{reg} = \frac{h_x - h_2}{h_4 - h_2}$$

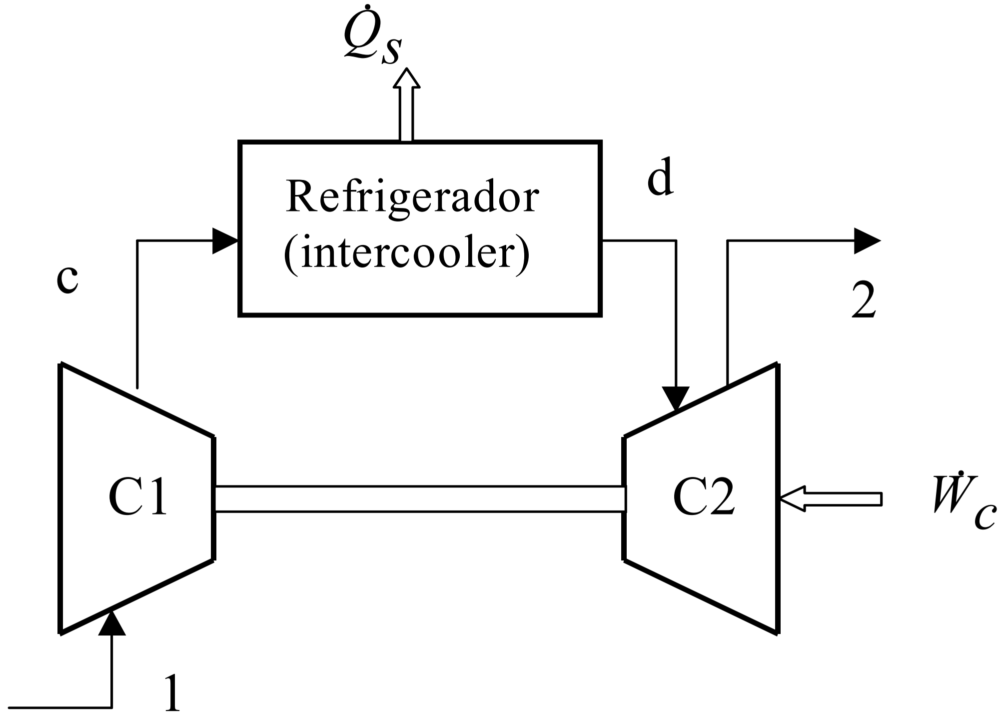


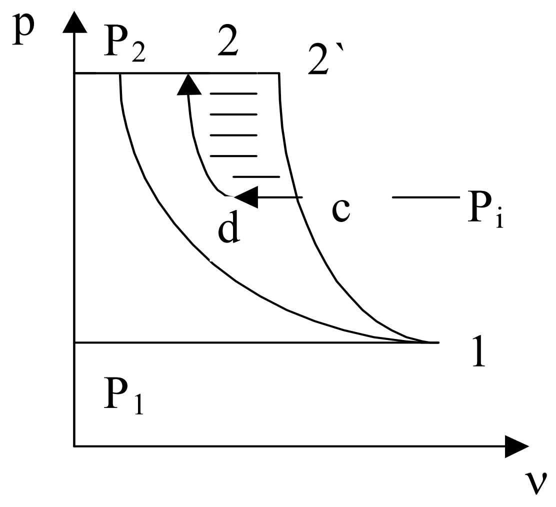
Turbina de gas con recalentamiento

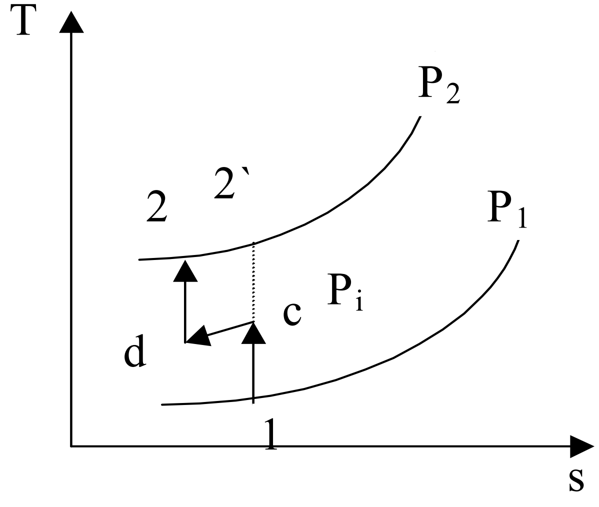




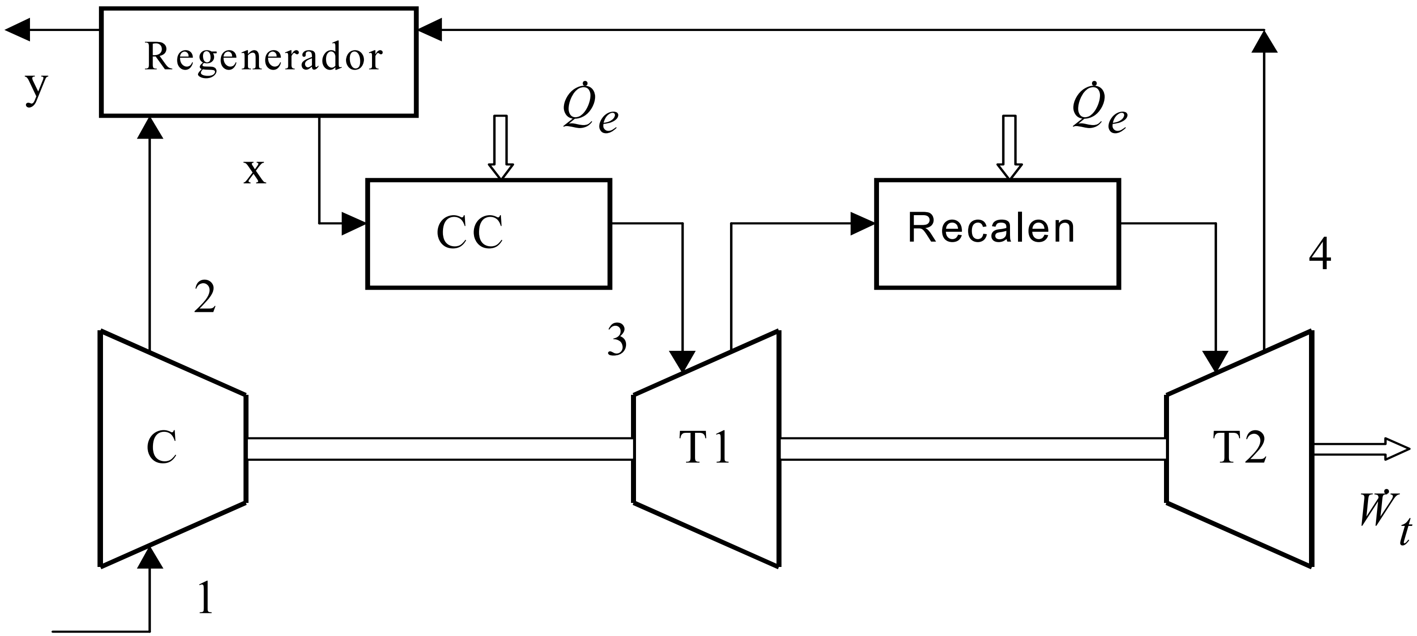
Turbina de gas con refrigeración en la compresión

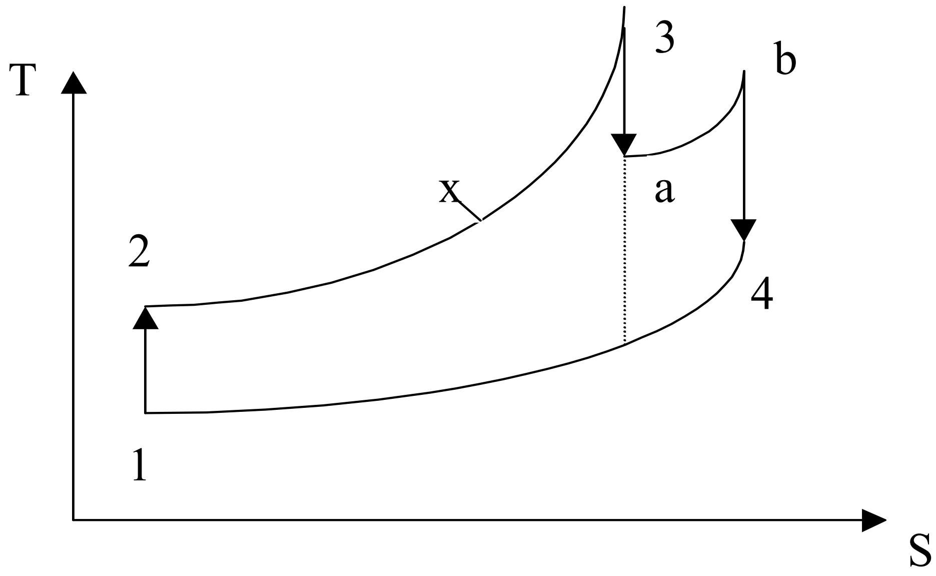






Turbina de gas regenerativa con recalentamiento





Turbina de gas regenerativa, con refrigeración en la compresión y recalentamiento intermedio