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1: "Proyecto de grado"
2:
3: "Ciclo Brayton abierto sin regeneración"
4:
5: "Estado 1"
6: T_1=23 [°C] "T media en Bucaramanga"
7: P_1=0,906592 [bar] "P atm en Bucaramanga"
8: h_1=Enthalpy(Air_ha;T=T_1;P=P_1)
9: s_1=Entropy(Air_ha;T=T_1;P=P_1)
10:
11: "Estado 2s"
12: s_2s=s_1
13: s_2s=Entropy(Air_ha;T=T_2s;P=P_2)
14: h_2s=Enthalpy(Air_ha;T=T_2s;P=P_2)
15: rp=2,869 "Calculado por punto máximo para máxima eficiencia"
16: rp=P_2/P_1
17:
18: "Estado 2"
19: h_2=Enthalpy(Air_ha;T=T_2;P=P_2)
20:
21: "Estado 3"
22: T_3=600
23: P_3=0,95*P_2
24: h_3=Enthalpy(Air_ha;T=T_3;P=P_3)
25: s_3=Entropy(Air_ha;T=T_3;P=P_3)
26:
27: "Estado 4s"
28: s_4s=s_3
29: s_4s=Entropy(Air_ha;T=T_4s;P=P_4)
30: h_4s=Enthalpy(Air_ha;T=T_4s;P=P_4)
31: P_4=P_1
32:
33: "Estado 4"
34: h_4=Enthalpy(Air_ha;T=T_4;P=P_4)
35:
36: "Eficiencias"
37: eta_c=0,7
38: eta_c=ws/wr
39: ws=h_2s-h_1
40: wr=h_2-h_1
41:
42: eta_t=0,8
43: eta_t=wr_t/ws_t
44: wr_t=h_3-h_4
45: ws_t=h_3-h_4s
46:
47:
48: "Ecuación de rendimiento térmico"
49:
50: w_neto=w_sal-w_ent
51: w_sal=eta_t*(w_sal_iso)
52: W_sal_iso=h_3-h_4s
53: w_ent=eta_c*(w_ent_iso)
54: w_ent_iso=h_2s-h_1
55:
56: eta_term=1-(q_sal/q_ent)
57: q_ent=h_3-h_2
58: q_sal=h_4-h_1
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*Proyecto de grado*

*Ciclo Brayton abierto sin regeneración*

*Estado 1*

$$T_1 = 23 \text{ [}^\circ\text{C]} \quad T \text{ media en Bucaramanga}$$

$$P_1 = 0,906592 \text{ [bar]} \quad P \text{ atm en Bucaramanga}$$

$$h_1 = h \left[ \text{Air}_{\text{ha}} ; T = T_1 ; P = P_1 \right]$$

$$s_1 = s \left[ \text{Air}_{\text{ha}} ; T = T_1 ; P = P_1 \right]$$

*Estado 2s*

$$s_{2s} = s_1$$

$$s_{2s} = s \left[ \text{Air}_{\text{ha}} ; T = T_{2s} ; P = P_2 \right]$$

$$h_{2s} = h \left[ \text{Air}_{\text{ha}} ; T = T_{2s} ; P = P_2 \right]$$

$$r_p = 2,869 \quad \text{Calculado por punto máximo para máxima eficiencia}$$

$$r_p = \frac{P_2}{P_1}$$

*Estado 2*

$$h_2 = h \left[ \text{Air}_{\text{ha}} ; T = T_2 ; P = P_2 \right]$$

*Estado 3*

$$T_3 = 600$$

$$P_3 = 0,95 \cdot P_2$$

$$h_3 = h \left[ \text{Air}_{\text{ha}} ; T = T_3 ; P = P_3 \right]$$

$$s_3 = s \left[ \text{Air}_{\text{ha}} ; T = T_3 ; P = P_3 \right]$$

*Estado 4s*

$$s_{4s} = s_3$$

$$s_{4s} = s \left[ \text{Air}_{\text{ha}} ; T = T_{4s} ; P = P_4 \right]$$

$$h_{4s} = h \left[ \text{Air}_{\text{ha}} ; T = T_{4s} ; P = P_4 \right]$$

$$P_4 = P_1$$

*Estado 4*

$$h_4 = h \left[ \text{Air}_{\text{ha}} ; T = T_4 ; P = P_4 \right]$$

*Eficiencias*

$$\eta_c = 0,7$$

$$\eta_c = \frac{w_s}{w_r}$$

$$ws = h_{2s} - h_1$$

$$wr = h_2 - h_1$$

$$\eta_t = 0,8$$

$$\eta_t = \frac{wr_t}{ws_t}$$

$$wr_t = h_3 - h_4$$

$$ws_t = h_3 - h_{4s}$$

### Ecuación de rendimiento térmico

$$W_{\text{neto}} = W_{\text{sal}} - W_{\text{ent}}$$

$$W_{\text{sal}} = \eta_t \cdot W_{\text{sal;iso}}$$

$$W_{\text{sal;iso}} = h_3 - h_{4s}$$

$$W_{\text{ent}} = \eta_c \cdot W_{\text{ent;iso}}$$

$$W_{\text{ent;iso}} = h_{2s} - h_1$$

$$\eta_{\text{term}} = 1 - \frac{q_{\text{sal}}}{q_{\text{ent}}}$$

$$q_{\text{ent}} = h_3 - h_2$$

$$q_{\text{sal}} = h_4 - h_1$$

### SOLUTION

#### Unit Settings: SI C bar kJ mass deg

$$\eta_c = 0,7$$

$$h_1 = 296,5$$

$$h_3 = 903,6$$

$$P_1 = 0,9066 \text{ [bar]}$$

$$P_4 = 0,9066 \text{ [bar]}$$

$$rp = 2,869 \text{ [1/bar]}$$

$$s_3 = 7,724$$

$$T_2 = 170,8$$

$$T_4 = 438,7$$

$$wr_t = 177$$

$$W_{\text{ent}} = 73,19$$

$$W_{\text{sal}} = 177$$

$$\eta_t = 0,8$$

$$h_2 = 445,8$$

$$h_4 = 726,6$$

$$P_2 = 2,601$$

$$q_{\text{ent}} = 457,8$$

$$s_1 = 6,886$$

$$s_{4s} = 7,724$$

$$T_{2s} = 126,8$$

$$T_{4s} = 397,5$$

$$ws = 104,6$$

$$W_{\text{ent;iso}} = 104,6$$

$$W_{\text{sal;iso}} = 221,3$$

$$\eta_{\text{term}} = 0,06039$$

$$h_{2s} = 401$$

$$h_{4s} = 682,3$$

$$P_3 = 2,471$$

$$q_{\text{sal}} = 430,1$$

$$s_{2s} = 6,886$$

$$T_1 = 23 \text{ [°C]}$$

$$T_3 = 600$$

$$wr = 149,4$$

$$W_{\text{St}} = 221,3$$

$$W_{\text{neto}} = 103,8$$

11 potential unit problems were detected.

EES suggested units (shown in purple) for P\_4 rp .

There are a total of 35 equations in the Main program.

Block	Rel. Res.	Abs. Res.	Units	Calls	Time(ms)	Equations
0	0.000E+00	0.000E+00	?	1	0	T_1=23[°C]
0	0.000E+00	0.000E+00	OK	1	0	P_1=0,906592[bar]
0	0.000E+00	0.000E+00	OK	1	0	rp=2,869
0	0.000E+00	0.000E+00	OK	1	0	T_3=600
0	0.000E+00	0.000E+00	OK	1	0	eta_c=0,7
0	0.000E+00	0.000E+00	OK	1	0	eta_t=0,8

0	0.000E+00	0.000E+00	?	4	15	<b>h_1</b> =Enthalpy(Air_ha;T=T_1;P=P_1)
0	0.000E+00	0.000E+00	?	4	0	<b>s_1</b> =Entropy(Air_ha;T=T_1;P=P_1)
0	0.000E+00	0.000E+00	OK	4	0	<b>s_2s</b> =s_1
0	0.000E+00	0.000E+00	OK	4	0	rp= <b>P_2</b> /P_1
0	0.000E+00	0.000E+00	OK	4	0	<b>P_3</b> =0,95*P_2
0	0.000E+00	0.000E+00	?	4	0	<b>h_3</b> =Enthalpy(Air_ha;T=T_3;P=P_3)
0	0.000E+00	0.000E+00	?	4	0	<b>s_3</b> =Entropy(Air_ha;T=T_3;P=P_3)
0	0.000E+00	0.000E+00	OK	4	0	<b>s_4s</b> =s_3
0	0.000E+00	0.000E+00	OK	4	0	<b>P_4</b> =P_1
0	1,570E-07	1,081E-06	?	6	0	s_2s=Entropy(Air_ha;T= <b>T_2s</b> ;P=P_2)
0	0.000E+00	0.000E+00	?	4	0	<b>h_2s</b> =Enthalpy(Air_ha;T=T_2s;P=P_2)
0	9,552E-08	7,379E-07	?	7	0	s_4s=Entropy(Air_ha;T= <b>T_4s</b> ;P=P_4)
0	0.000E+00	0.000E+00	?	4	0	<b>h_4s</b> =Enthalpy(Air_ha;T=T_4s;P=P_4)
0	0.000E+00	0.000E+00	OK	4	0	<b>ws</b> =h_2s-h_1
0	0.000E+00	0.000E+00	OK	4	0	<b>ws_t</b> =h_3-h_4s
0	0.000E+00	0.000E+00	OK	4	0	<b>w_sal_iso</b> =h_3-h_4s
0	0.000E+00	0.000E+00	OK	4	0	<b>w_ent_iso</b> =h_2s-h_1
0	0.000E+00	0.000E+00	OK	4	0	eta_c=ws/wr
0	0.000E+00	0.000E+00	OK	4	0	wr= <b>h_2</b> -h_1
0	0.000E+00	0.000E+00	OK	4	0	eta_t= <b>wr_t</b> /ws_t
0	7,840E-20	-1,388E-17	OK	4	0	wr_t=h_3-h_4
0	0.000E+00	0.000E+00	OK	4	0	<b>w_sal</b> =eta_t*(w_sal_iso)
0	0.000E+00	0.000E+00	OK	4	0	<b>w_ent</b> =eta_c*(w_ent_iso)
0	0.000E+00	0.000E+00	OK	4	0	<b>q_ent</b> =h_3-h_2
0	0.000E+00	0.000E+00	OK	4	0	<b>q_sal</b> =h_4-h_1
0	6,008E-10	2,679E-07	?	5	0	h_2=Enthalpy(Air_ha;T= <b>T_2</b> ;P=P_2)
0	5,996E-11	-4,357E-08	?	6	0	h_4=Enthalpy(Air_ha;T= <b>T_4</b> ;P=P_4)
0	0.000E+00	0.000E+00	OK	4	0	<b>w_net</b> =w_sal-w_ent
0	0.000E+00	0.000E+00	OK	4	0	eta_term=1-(q_sal/q_ent)

**Parametric Table: Table 2**

	rp	w <sub>net</sub>
	[1/bar]	
Run 1	1	-10,36
Run 2	1,474	40,25
Run 3	1,947	70,38
Run 4	2,421	90,37
Run 5	2,895	104,5
Run 6	3,368	114,8
Run 7	3,842	122,6
Run 8	4,316	128,6
Run 9	4,789	133,3
Run 10	5,263	136,9
Run 11	5,737	139,7
Run 12	6,211	141,9
Run 13	6,684	143,5
Run 14	7,158	144,8
Run 15	7,632	145,7
Run 16	8,105	146,3
Run 17	8,579	146,7
Run 18	9,053	146,8
Run 19	9,526	146,8
Run 20	10	146,7

