

# TALLER DE MÁQUINAS TÉRMICAS

VERGARA PAREJA GUSTAVO  
MARTÍNEZ CAUSIL CARLOS ALBERTO  
SOTO SUÁREZ IVÁN ESTEBAN  
QUINTERO MARTÍNEZ JEAN PAUL

BERNARDO J. LUJÁN E.  
MÁQUINAS TÉRMICAS - G2IM  
UNIVERSIDAD DE CÓRDOBA  
13 DE NOVIEMBRE DE 2024

## Equations

## Turbina

$$\text{procedure } \textit{Analisis}_{\textit{Turbina}}(h_{in}, s_{in}, P_{in}, P_{out}, \eta_t : h_{out}, s_{out}, T_{out}) \quad (1)$$

$$h_{s,out} = h(Water, s = s_{in}, P = P_{out}) \quad (2)$$

$$h_{out} = h_{in} - \eta_t \cdot (h_{in} - h_{s,out}) \quad (3)$$

$$s_{out} = s(Water, P = P_{out}, h = h_{out}) \quad (4)$$

$$T_{out} = T(Water, P = P_{out}, h = h_{out}) \quad (5)$$

end (6)

Bomba

$$\text{procedure } \textit{Analisis}_{\textit{Bomba}}(h_{in}, s_{in}, P_{in}, P_{out}, \eta_b : h_{out}, s_{out}, T_{out}) \quad (7)$$

$$h_{s,out} = h(Water, s = s_{in}, P = P_{out}) \quad (8)$$

$$h_{out} = \left( \frac{h_{s,out} - h_{in}}{\eta_b} \right) + h_{in} \quad (9)$$

$$s_{out} = s(Water, P = P_{out}, h = h_{out}) \quad (10)$$

$$T_{out} = T(Water, P = P_{out}, h = h_{out}) \quad (11)$$

$$\text{end} \tag{12}$$

### Condiciones de operacin.....

$$\dot{m}_b = 2,5 \text{ [kg/s]} \quad (13)$$

$$P_b = 10 \cdot |1 \ 1| \quad (14)$$

$$T_{hf,in} = 450 \quad (15)$$

[illegible]

$$P_{ext,1} = 1,1 \times 10^3 \text{ [kPa]} \quad (16)$$

$$P_{ext,2} = 0,25 \times 10^3 \text{ [kPa]} \quad (17)$$

$$P_{ext.3} = 0,1 \times 10^3 \text{ [kPa]} \quad (18)$$

## Eficiencias

$$\eta_{T,1} = 0,87 \quad (19)$$



#### Estado 5

$$P_5 = P_4 \quad (42)$$

$$T_5 = T_{hf,in} - \Delta T_{rh} \quad (43)$$

$$h_5 = h(Water, T = T_5, P = P_5) \quad (44)$$

$$s_5 = s(Water, T = T_5, P = P_5) \quad (45)$$

#### Estado 6

$$P_6 = P_{ext,3} \quad (46)$$

$$\text{call } Analisis_{Turbina}(h_5, s_5, P_5, P_6, \eta_{T,3} : h_6, s_6, T_6) \quad (47)$$

#### Estado 7

$$P_7 = P_8 \quad (48)$$

$$\text{call } Analisis_{Turbina}(h_6, s_6, P_6, P_7, \eta_{T,4} : h_7, s_7, T_7) \quad (49)$$

#### Estado 8

$$T_8 = T_c + \Delta T_{cond} \quad (50)$$

$$P_8 = P_{sat}(Water, T = T_8) \quad (51)$$

$$h_8 = h(Water, T = T_8, x = 0) \quad (52)$$

$$s_8 = s(Water, T = T_8, x = 0) \quad (53)$$

#### Estado 9

$$P_9 = P_6 \quad (54)$$

$$\text{call } Analisis_{Bomba}(h_8, s_8, P_8, P_9, \eta_{P,1} : h_9, s_9, T_9) \quad (55)$$

#### Estado 10

$$P_{10} = P_9 \quad (56)$$

$$h_{10} = h(Water, P = P_{10}, x = 0) \quad (57)$$

$$s_{10} = s(Water, P = P_{10}, x = 0) \quad (58)$$

$$T_{10} = T(Water, P = P_{10}, h = h_{10}) \quad (59)$$

#### Estado 11

$$P_{11} = P_1 \quad (60)$$

$$\text{call } Analisis_{Bomba}(h_{10}, s_{10}, P_{10}, P_{11}, \eta_{P,2} : h_{11}, s_{11}, T_{11}) \quad (61)$$

#### Estado 12

$$T_{12} = T_{13} - \Delta T_{CAA,C} \quad (62)$$

$$P_{12} = P_{11} \quad (63)$$

#### Turbina 2

$$\dot{W}_{T2} = \dot{m}_b \cdot (1 - f_1) \cdot (h_3 - h_4) \quad (79)$$

#### Turbina 3

$$\dot{W}_{T3} = \dot{m}_b \cdot (1 - f_1) \cdot (h_5 - h_6) \quad (80)$$

#### Turbina 4

$$\dot{W}_{T4} = \dot{m}_b \cdot (1 - f_1) \cdot (1 - f_2) \cdot (h_6 - h_7) \quad (81)$$

#### Bomba 1

$$\dot{W}_{P1} = \dot{m}_b \cdot (1 - f_1) \cdot (1 - f_2) \cdot (h_9 - h_8) \quad (82)$$

#### Bomba 2

$$\dot{W}_{P2} = \dot{m}_b \cdot (1 - f_1) \cdot (h_{11} - h_{10}) \quad (83)$$

#### Bomba 3

$$\dot{W}_{P3} = \dot{m}_b \cdot f_1 \cdot (h_{14} - h_{13}) \quad (84)$$

#### Trabajo Neto

$$\dot{W}_{Neto} = \dot{W}_{T4} + \dot{W}_{T3} + \dot{W}_{T2} + \dot{W}_{T1} - (\dot{W}_{P3} + \dot{W}_{P2} + \dot{W}_{P1}) \quad (85)$$

#### Calor de entrada

$$\dot{Q}_{in} = \dot{Q}_b + \dot{Q}_{rh} \quad (86)$$

#### Eficiencia

$$\eta_{ciclo} = \dot{W}_{Neto} / \dot{Q}_{in} \quad (87)$$

### Solution

#### Variables in Main program

$\Delta T_b = 15 \text{ [C]}$	$\Delta T_{CAA,C} = 2 \text{ [C]}$	$\Delta T_{cond} = 5 \text{ [C]}$	$\Delta T_{rh} = 10 \text{ [C]}$	$\eta_{ciclo} = 0,3984$
$\eta_{P,1} = 0,65$	$\eta_{P,2} = 0,67$	$\eta_{P,3} = 0,69$	$\eta_{T,1} = 0,87$	$\eta_{T,2} = 0,9$
$\eta_{T,3} = 0,92$	$\eta_{T,4} = 0,93$	$f_1 = 0,1482$	$f_2 = 0,09141$	$\dot{m}_b = 2,5 \text{ [kg/s]}$
$P_b = 10000 \text{ [kPa]}$	$P_{ext,1} = 1100 \text{ [kPa]}$	$P_{ext,2} = 250 \text{ [kPa]}$	$P_{ext,3} = 100 \text{ [kPa]}$	$\dot{Q}_b = 6049 \text{ [kW]}$
$\dot{Q}_{cond} = -4710 \text{ [kW]}$	$\dot{Q}_{in} = 7829 \text{ [kW]}$	$\dot{Q}_{rh} = 1780 \text{ [kW]}$	$T_c = 30 \text{ [C]}$	$T_{hf,in} = 450 \text{ [C]}$
$\dot{W}_{Neto} = 3119 \text{ [kW]}$	$\dot{W}_{P1} = 0,2826 \text{ [kW]}$	$\dot{W}_{P2} = 32,75 \text{ [kW]}$	$\dot{W}_{P3} = 5,401 \text{ [kW]}$	$\dot{W}_{T1} = 1100 \text{ [kW]}$

$$\dot{W}_{T2} = 502 \text{ [kW]} \quad \dot{W}_{T3} = 532,8 \text{ [kW]} \quad \dot{W}_{T4} = 1022 \text{ [kW]}$$

### Key Variables

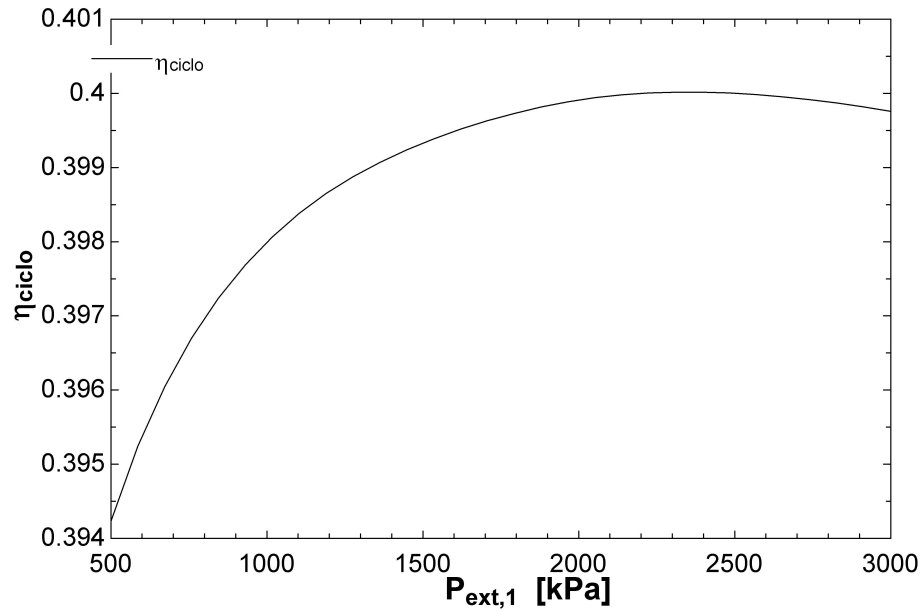
$$\eta_{ciclo} = 0,3984 \text{ *Eficiencia del ciclo*}$$

1. La eficiencia del ciclo se muestra a continuación:

$$\eta_{ciclo} = 0,3984 \text{ Eficiencia del ciclo}$$

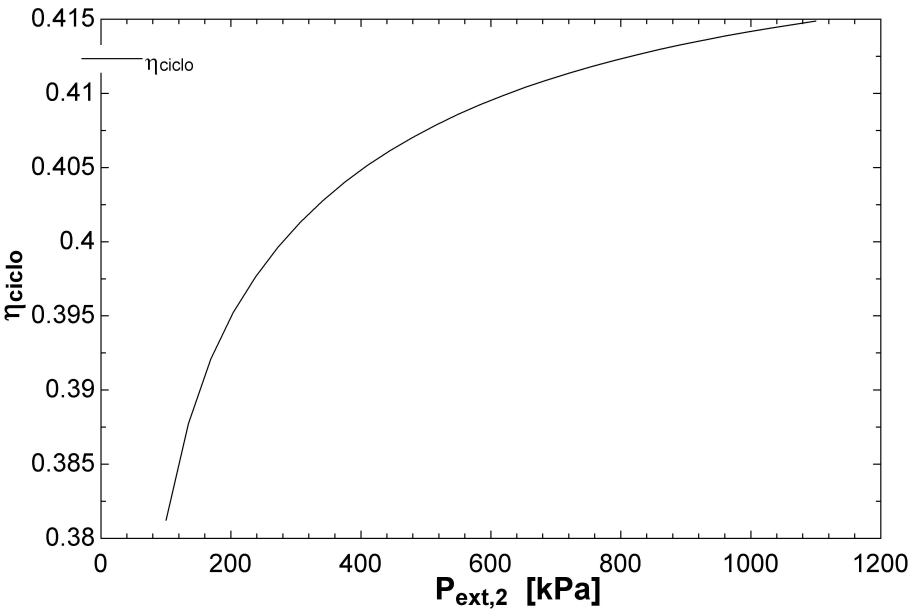
2. Para optimizar el ciclo y analizar el comportamiento de su eficiencia, se requiere ajustar las presiones de extracción. Para ello, se emplearon tablas paramétricas en las que se variaron los valores de la primera presión de extracción. A partir de estos valores, se inició un proceso iterativo que resultó en un incremento de la eficiencia, conforme a la teoría del ciclo Rankine. Posteriormente, se generaron gráficos que muestran la relación entre cada presión de extracción y la eficiencia, los cuales se presentan en los gráficos No.1, No.2 y No.3.

**Plot Window 1: Plot 1**

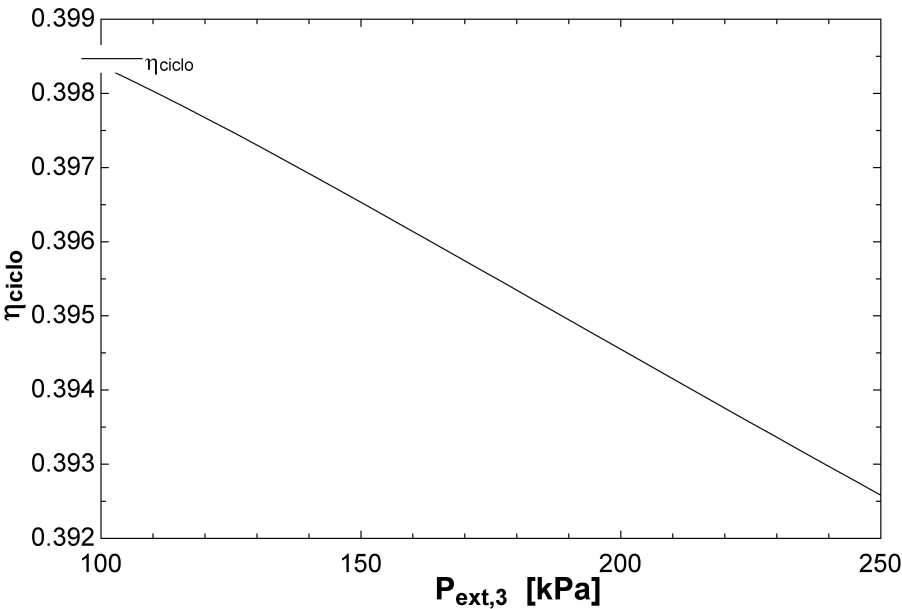




Plot Window 2: Plot 2



Plot Window 3: Plot 3



	$\eta_{ciclo}$	$P_{ext,1}$ [kPa]	$P_{ext,2}$ [kPa]	$P_{ext,3}$ [kPa]
Run 1	0.3938	100	1000	100
Run 2	0.4042	269	1000	100
Run 3	0.4084	437.9	1000	100
Run 4	0.4108	606.9	1000	105.2
Run 5	0.4124	775.9	1000	113.9
Run 6	0.4136	944.8	1000	121.4
Run 7	0.4144	1114	1000	128.2
Run 8	0.415	1283	1000	134.3
Run 9	0.4155	1452	1000	139.9
Run 10	0.416	1621	1000	145.2
Run 11	0.4163	1790	1000	150.2
Run 12	0.4166	1959	1000	154.9
Run 13	0.4168	2128	1000	159.3
Run 14	0.417	2297	1000	163.6
Run 15	0.4171	2466	1000	167.8
Run 16	0.4171	2634	1000	171.8
Run 17	0.4171	2803	1000	175.6
Run 18	0.4171	2972	1000	179.4
Run 19	0.4171	3141	1000	183
Run 20	0.417	3310	1000	186.5
Run 21	0.4169	3479	1000	189.9
Run 22	0.4168	3648	1000	193.3
Run 23	0.4167	3817	1000	196.6
Run 24	0.4165	3986	1000	199.8
Run 25	0.4164	4155	1000	202.9
Run 26	0.4162	4324	1000	206
Run 27	0.416	4493	1000	209
Run 28	0.4158	4662	1000	211.9
Run 29	0.4156	4831	1000	214.8
Run 30	0.4154	5000	1000	217.7

Figura 1: Eficiencia vs variación de presión de extracción

Como resultado de la optimización con una eficiencia de  $\eta_{ciclo} = 0,4171$ , se determinó que la configuración óptima de las presiones de extracción para el ciclo completo es:

- $P_{ext1} = 2466$  kPa
- $P_{ext2} = 1000$  kPa
- $P_{ext3} = 167,8$  kPa

3. A partir de lo estados definidos, se grafica en un diagrama T vs S, y se obtiene el resultado el siguiente gráfico:

**Plot Window 4: T-s: Water**

