homework (/github/mschrader15/homework/tree/main)
/ fall-2021 (/github/mschrader15/homework/tree/main/fall-2021)
/ me-591 (/github/mschrader15/homework/tree/main/fall-2021/me-591)

HW 10

Max Schrader

Please provide answers to the following questions at the end of chapter 8 of your textbook:

1. 9-11
2. 9-25

In [3]:
```
from hw_setup import *
```

9-11

An open-system OTEC power plant operates with a surface water temperature of 27°C and a deep water temperature of 13°C. The evaporator is maintained at a saturation pressure of 3.17 kPa and a saturation temperature of 25°C and condenser pressure and temperature at saturation con- dition are 1.706 kPa and 15°C, respectively. The mass flow rate of warm surface water entering the evaporator is 1000 kg/s and the turbine has an isentropic efficiency of 80 percent. Determine (a) the mass flow rate of steam at the turbine inlet, (b) the volume flow rates of steam at the turbine inlet and outlet, (c) the turbine power output and the thermal efficiency of the cycle, and (d) the mass flow rate of cold deep water. Neglect pumping power and other internal or auxiliary power consumptions in the plant.

In [7]:
```
T_1 = 27 * ureg.degC
x_1 = 0
m_dot = 1000 * ureg.kg / ureg.sec

P_2 = 3.17 * ureg.kPa
T_2 = 25 * ureg.degC

P_5 = 1.706 * ureg.kPa
T_5 = 15 * ureg.degC
```

Properties at the Evaporator

In [50]:

```
h_1 = (125.74 - 104.83) / (30 - 25) * (27 - 25) + 104.83
h_1 = h_1 * ureg.kJ / ureg.kg
h_1
```

Out[50]:

113.194 kilojoule/kilogram

In [52]:

```
h_2 = h_1
```

In [53]:

```
T_2 = 25 * ureg.degC
h_4 = 104.83 * ureg.kJ / ureg.kg
h_3 = 2546.5 * ureg.kJ / ureg.kg
```

In [54]:

```
s_3 = 8.5567 * ureg.kg / (ureg.kJ * ureg.degK)
v_3 = 43.340 * ureg.meter ** 3 / ureg.kg
```

In [55]:

```
x_2 = (h_2 - h_4) / (h_3 - h_4)
x_2
```

Out[55]:

0.0034255243337551772 dimensionless

a) Mass Flow Rate of Steam at Turbine Inlet

In [56]:

```
m_dot_3 = x_2 * m_dot
m_dot_3
print_msg_box(f"Mass Flow Rate of Steam: {round(m_dot_3, 2)}")
```

```
Mass Flow Rate of Steam: 3.43 kilogram / second
```

b) the volume flow rates of steam at the turbine inlet and outlet

In [57]:

```
V_3 = m_dot_3 * v_3
print_msg_box(f"Volume flow rate of steam in: {round(V_3, 2)}")
```

```
Volume flow rate of steam in: 148.46 meter ** 3 / second
```

In [58]:

```
x_5s = 1 - (8.7803 - s_3.magnitude) / 8.5559
h_5s = (x_5s * 2465.4 + 62.982) * ureg.kJ / ureg.kg
```

In [59]:

```
h_5 = (.8 * (h_3 -  h_5s) - h_3) * -1
h_5
```

Out[59]:

2480.4609639009336 kilojoule/kilogram

In [60]:

```
v_5 = 77.885 * ureg.meter ** 3 / ureg.kg
V_5 = m_dot_3 * v_5
print_msg_box(f"Volume flow rate of steam out: {round(V_5, 2)}")
```

```
Volume flow rate of steam out: 266.8 meter ** 3 / second
```

c) the turbine power output and the thermal efficiency of the cycle

In [62]:

```
W_dot_out = m_dot_3 * (h_3 - h_5)
print_msg_box(f"Power Output = {round(W_dot_out.to('kW'), 2)}")
```

```
Power Output = 226.22 kilowatt
```

In [63]:

```
Q_in = m_dot * h_1 - m_dot_3 * h_4
```

In [64]:

```
n_th = W_dot_out / Q_in
n_th
```

Out[64]: 0.002004861266822587 dimensionless

In [66]:

```
print_msg_box(f"Thermal Efficiency = {round((n_th * 100).magnitude
```

```
Thermal Efficiency = 0.2%
```

d) The mass flow rate of cold deep water

In [73]:

```
h_6 = 52 * ureg.kJ / ureg.kg
h_7 = 62.980 * ureg.kJ / ureg.kg
```

In [76]:

```
print_msg_box(f"Mass Flow Rate Cold Water = {(m_dot_3 * h_5 - (m_d
```

```
Mass Flow Rate Cold Water = 754.2021737916732 kilogram / second
```

9-25

An ocean wave is 4-m-high and lasts for a period of 3.5 s. Determine (a) the wavelength and the wave velocity and (b) the work and power potentials per unit area. Take the density of seawater to be 1025 kg/m3

In [105]:
```
tau = 3.5 * ureg.sec
a = 4 * ureg.meter / 2
density = 1025 * (ureg.kg / ureg.meter ** 3)
```

In [87]:
```
lambda_ = 1.56 * tau ** 2
lambda_ = lambda_.magnitude * ureg.meter
```

In [88]:
```
print_msg_box(f"Wave Length = {round(lambda_, 3)}")
```

```
Wave Length = 19.11 meter
```

In [89]:
```
V = lambda_ / tau
V
```

Out[89]: 5.46 meter/second

In [90]:
```
print_msg_box(f"Wave Velocity = {round(V, 3)}")
```

```
Wave Velocity = 5.46 meter / second
```

In [91]:
```
m = 2 * math.pi / lambda_
m
```

Out[91]: 0.32879043993613744 1/meter

In [118]:
```
w_available = 1/2 * density * a ** 2 * 9.81 * (ureg.meter / ureg.s
```

In [120]:
```
print_msg_box(f"Work Potential per Unit Area = {round(w_available.
```

```
Work Potential per Unit Area = 20110.5 joule / meter ** 2
```

In [121]:
```
w_dot_available = (1 / (2 * tau)) * density * a ** 2 * ureg.gravit
```

In [124]:
```
print_msg_box(f"Wave Power Potential  = {round(w_dot_available.to(
```

```
Wave Power Potential  = 5743.895 watt / meter ** 2
```