Tutorial

- Draw a phasor diagram for a 50 K OPTC with Helium as working fluid. The other operating parameters are as given below.

Parameters
Frequency: 30 Hz
Charge pressure: 20 bar (abs)
Dynamic pressure: 4 bar (abs)
PT volume: 8 cc
Regenerator Volume : 20 cc
Compressor dead volume: 20 cc
Heat exchanger volume: 2 cc
Temperature: 300 K
Orifice mass flow rate: 2 gm/s

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Given	
$f = 30\ Hz$	$V_{PT} = 8 \ X\ 10^{-6}$
$p_o = 20\ bar$	$V_{Regen} = 20\ X\ 10^{-6}$
$p_1 = 4\ bar$	$V_{HX} = 2\ X\ 10^{-6}$
$T_o = 300\ K$	$V_{CP} = 20\ X\ 10^{-6}$
$T_c = 50\ K$	$m_o = 2\ X\ 10^{-3}$

Required
Phasor Diagram
Phase angle $\mathbf{m_c}$ and pressure vector
Phase angle $\mathbf{m_{cp}}$ and pressure vector

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- $\mathbf{m_o = m_h}$ = 0.002 Kg/s.

- Pressure Vector: $$m_h\left(\frac{T_h}{T_c}\right) = 0.002\left(\frac{300}{50}\right)$$

$$= 0.012$$

- Mass flow rate at Hot end (kg/s).

$$\frac{\omega p_1 V_{hhx}}{RT_h} = \frac{2\pi(30)(4)(10^5)(2)(10^{-6})}{(2078.5)(300)}$$

$$= 0.2418(10^{-3})$$

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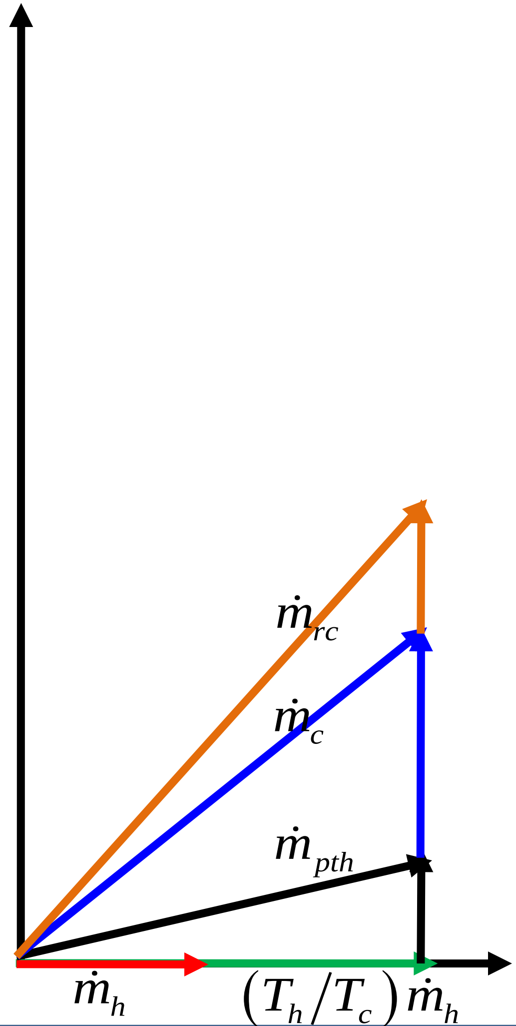


- Mass flow rate in Pulse Tube (kg/s).

$$\frac{\omega p_1 V_{pt}}{\gamma R T_c} = \frac{2\pi(30)(4)(10^5)(8)(10^{-6})}{(1.67)(2078.5)(300)}$$

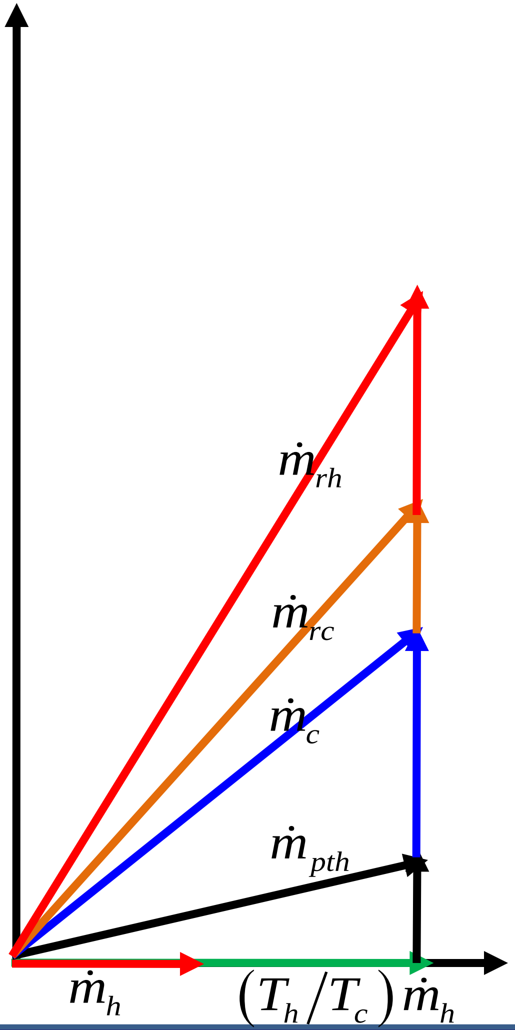
$$= 3.482(10^{-3})$$

- Mass flow rate in Cold end (kg/s).

$$\frac{\omega p_1 V_{chx}}{R T_c} = \frac{2\pi(30)(4)(10^5)(2)(10^{-6})}{(2078.5)(50)}$$

$$= 1.451(10^{-3})$$

Tutorial



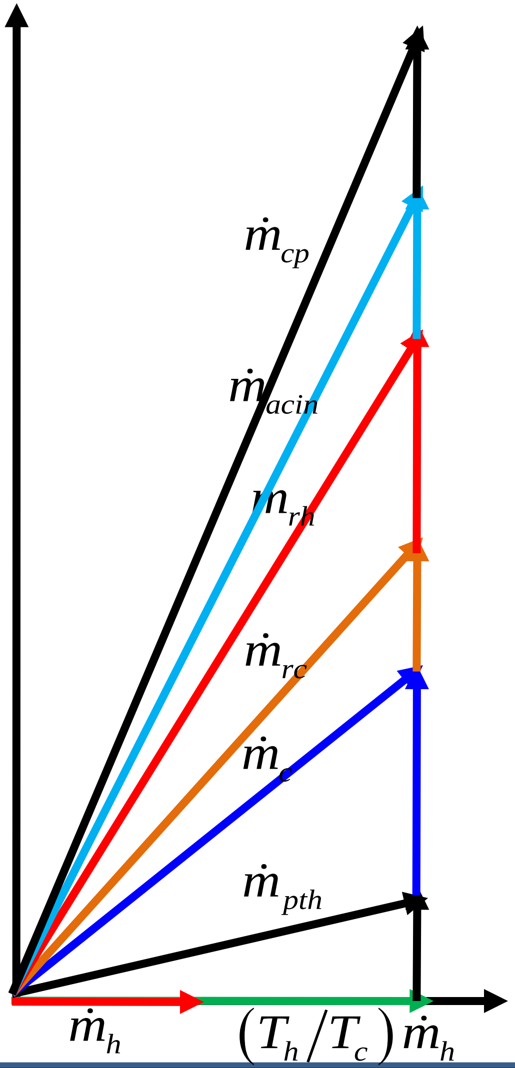
- Mass flow rate in Regenerator (kg/s).

$$T_m = \frac{T_h - T_c}{\ln(T_h/T_c)} = \frac{300-50}{\ln(300/50)} = 139.5$$

$$\frac{\omega p_1 V_{regen}}{RT_m} = \frac{2\pi(30)(4)(10^5)(20)(10^{-6})}{(2078.5)(139.5)}$$

$$= 5.2(10^{-3})$$

Tutorial



- Mass flow rate in After cooler (kg/s).

$$\frac{\omega p_1 V_{hhx}}{RT_h} = \frac{2\pi(30)(4)(10^5)(2)(10^{-6})}{(2078.5)(300)}$$

$$= 0.2418(10^{-3})$$

- Mass flow rate in Compressor (kg/s).

$$\frac{\omega p_1 V_{cpd}}{RT_0} = \frac{2\pi(30)(4)(10^5)(20)(10^{-6})}{(2078.5)(300)}$$

$$= 2.418(10^{-3})$$

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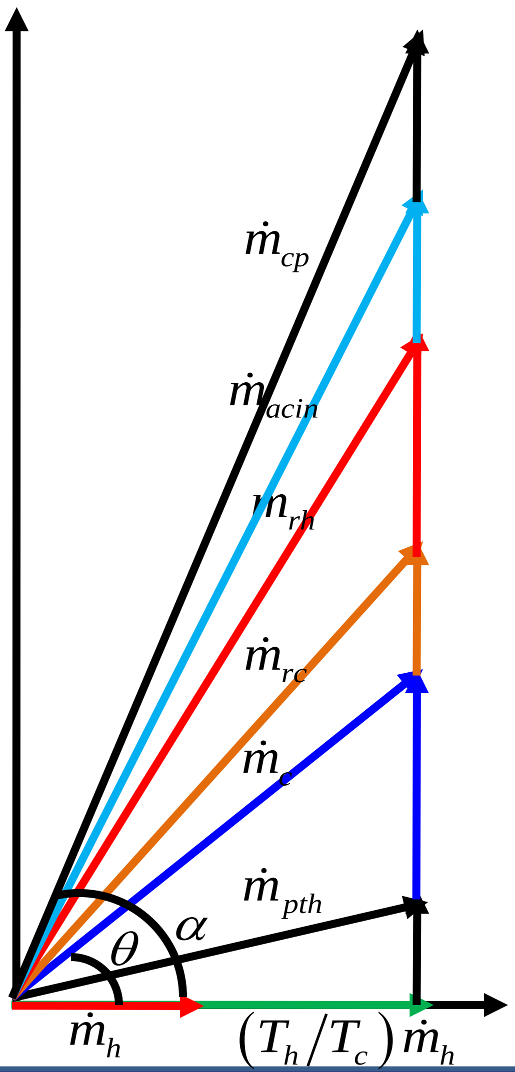

- The phase angle between the mass flow rate at the cold end and the pressure vector is

$m_c = 13.1\, g/s$ $\theta = 23.3^o$

- The phase angle between the mass flow rate in the compressor and the pressure vector is

$m_{cp} = 16.0\, g/s$ $\alpha = 47.4$

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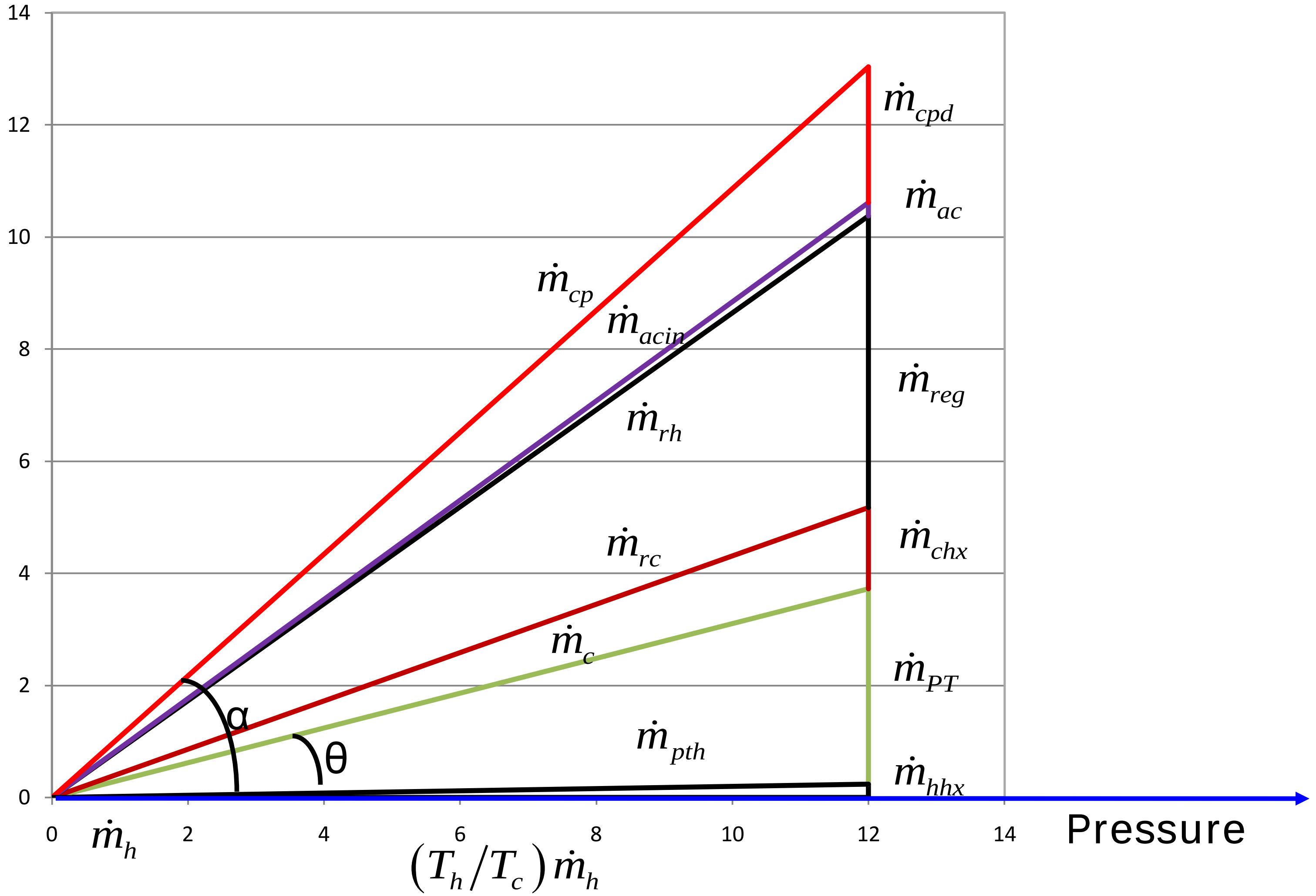
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
$\dot{m}_{cpd}$
$\dot{m}_{ac}$
$\dot{m}_{cp}$
$\dot{m}_{acin}$
$\dot{m}_{reg}$
$\dot{m}_{rh}$
$\dot{m}_{chx}$
$\dot{m}_{rc}$
$\dot{m}_{c}$
$\dot{m}_{PT}$
α
θ
$\dot{m}_{pth}$
$\dot{m}_{hhx}$
$\dot{m}_h$
$(T_h/T_c)\,\dot{m}_h$
Pressure