Respiratory System Unit

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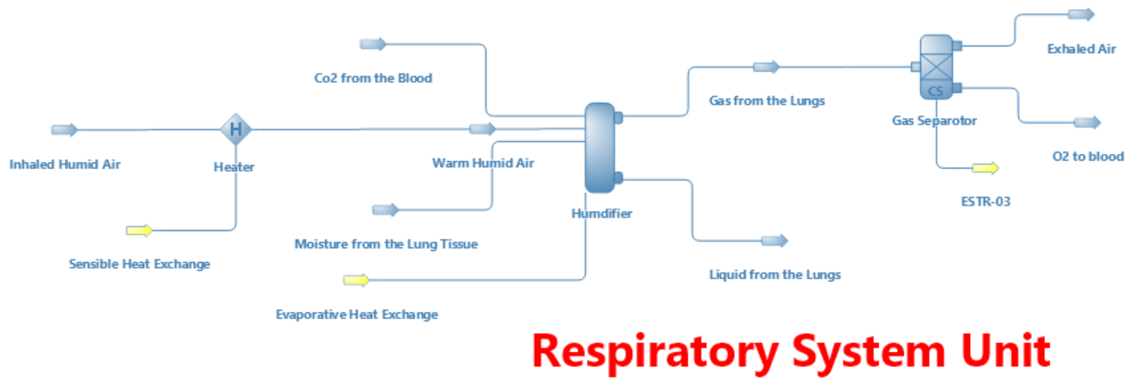
Background:

One of the most challenging aspects of coronavirus disease 2019 (COVID-19) is that a newly infected individual shows diagnosable symptoms, such as body temperature rise, several days after contracting the disease. In the early phase of infection (i.e., incubation period), an undiagnosed and unaware individual can spread the virus to others. The fastest and most efficient route of COVID-19 transmission is the respiratory system. Therefore, developing a model of the respiratory system to predict changes in the lung performance upon COVID-19 infection is useful for early diagnosis and intervention during the incubation period.

Flowsheet:



Process Description:

A simple model was developed by performing mass and energy balances on the lungs; it was simulated by the DWSIM chemical process simulator using Peng Robinson Method.

Inhaled Humid Air (Material Stream) Consists of 20^0 C at 101.3 KPa having 0.01607 Kmole/hr molar flow with mole fractions Oxygen of 0.2076, Nitrogen of 0.7808 and water of 0.0116 And **Sensible Heat Exchange** (Energy stream) was fed into the **Heater.** The **heater** having **Warm Humid Air (**outlet material stream) with **ΔP** 0Kpa and **ΔT** 17^0 C in the heater.

Co_2 from the blood (Material Stream) having 37^0C at 101.3 Kpa and 0.00142 Kmol/hr with Co_2 mole fraction 1, **Moisture from the lung tissue** (Material Stream) having 37^0C at 101.3 Kpa and 0.0008862 Kmol/hr with H_2O mole fraction 1, **Evaporative Heat Exchange** (Energy Stream) was fed into **Humidifier(**Gas-Liquid separator) with operation conditions 37^0C at 101.3 Kpa having **Gas from the lungs**(Vapour Stream) and **Liquid from the lungs** (Liquid-liquid Stream) as outlet streams.

Gas from the lungs is fed into a **Gas Separator** (Component Separator) with **Exhaled Air** (Outlet stream 1) and **O2 to blood** (Outlet stream 2) used oxygen fraction of 1 in outlet stream 2 as spec.

Results:

Results obtained from the flowsheet					
Object	**Inhaled Humid Air**	**Gas from Lungs**	**Exhaled Air**	**O2 to blood**	**Units**
Temperature	20	37	37	37	C
Pressure	1.013	1.013	1.013	1.013	bar
Molar Flow	0.01607	0.018298	0.018264	3.34E-05	kmol/h
Molar Flow (Vapor)	0.01607	0.018298	0.018263	3.34E-05	kmol/h
Molar Fraction (Vapor) / Nitrogen	0.7808	0.685738	0.687063	0	
Molar Fraction (Vapor) / Oxygen	0.2076	0.182325	0.18085	1	
Molar Fraction (Vapor) / Carbon dioxide	0	0.077605	0.077755	0	
Molar Fraction (Vapor) / Water	0.0116	0.054332	0.054332	0	

Conclusion: To compensate for the virus-infected lung inefficiency, the O2 concentration increased in the exhaled air at the cost of decreased CO2 concentration. Contrary to previous findings on the reduced stability of coronavirus in hot and humid environments, it was found that very hot and humid environments promote the viral transmission rate because of the direct heat transfer to the body via respiration and condensation of water vapour that may cause infection in the respiratory tract.

Reference:

Hejazi B, Hejazi K. A Modeling Study of the Respiratory System for an Early Intervention of COVID-19 and Its Transmission, Int J Infect. 2021; 8(2):e110410. DOI:10.5812/iji.110410