CINTI 2020

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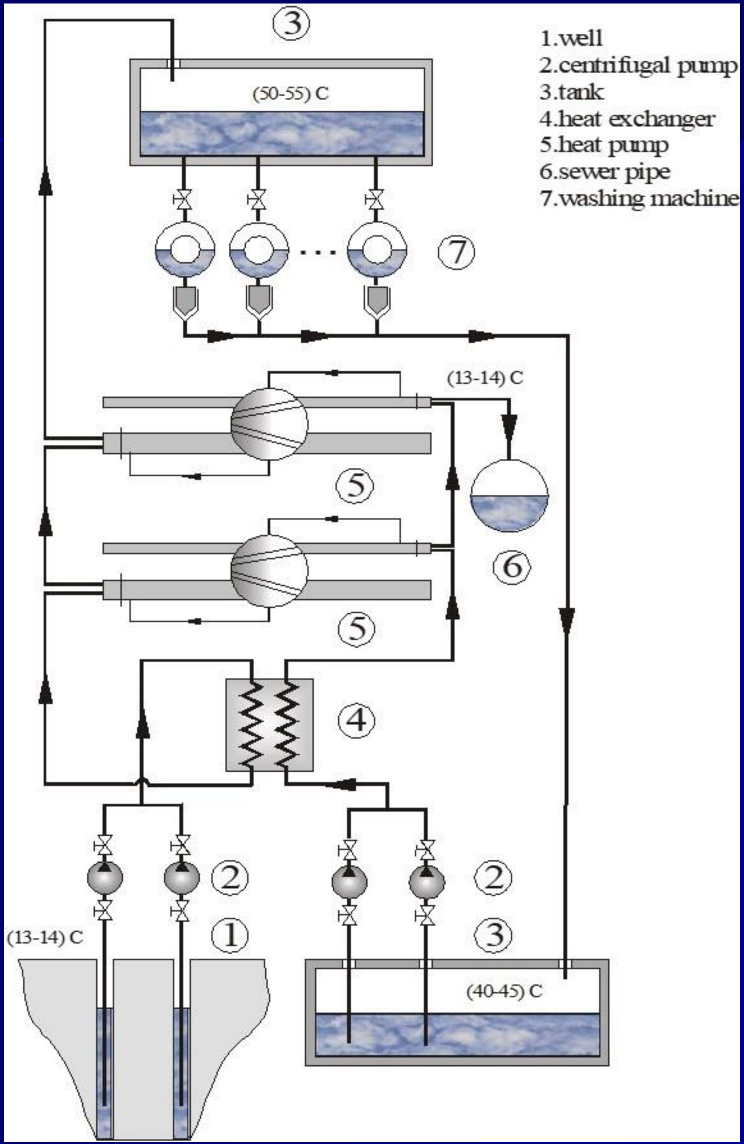
1. Introduction:

We have to establish a precise mathematical model based on the physical model with stationary operation mode, containing equations of the heat pump’s evaporator and it’s connected components.

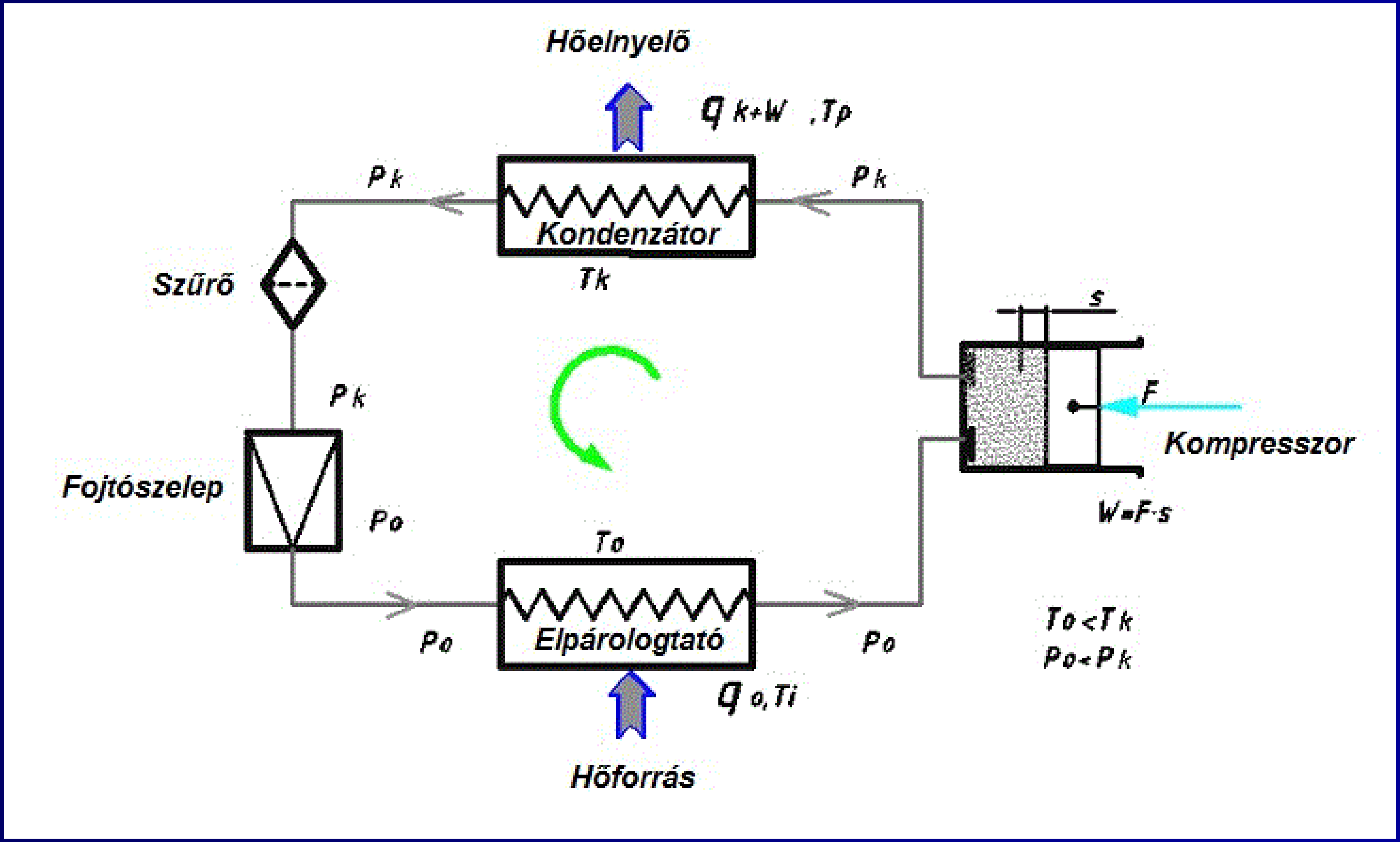
2. Physical model:

- (1) Two 40 meters deep wells as the source of clean water,
- (2) Two centrifugal pumps for pumping the clean water from the wells and two centrifugal pumps for circulating the waste water beetwen tank and sewer
- (3) Plate heat exchanger,
- (4) Heat pump for low temperatures,
- (5) Heat pump for high temperatures
- (6) Tank for hot clean water,
- (7) Washing machines,
- (8) Tank for hot wastewater,
- (9) Two centrifugal pumps for pumping and transporting wastewater,
- (10) Sewer system for wastewater draining,

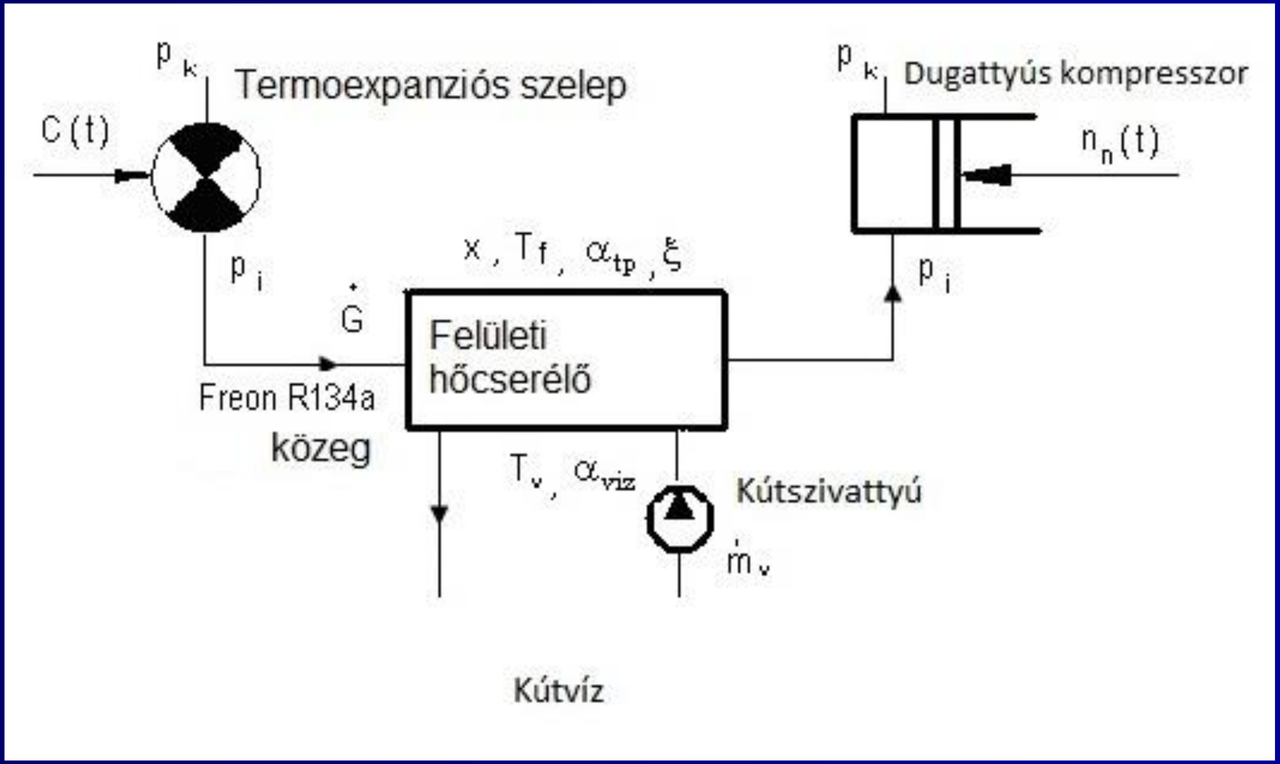
2.1 General physical model



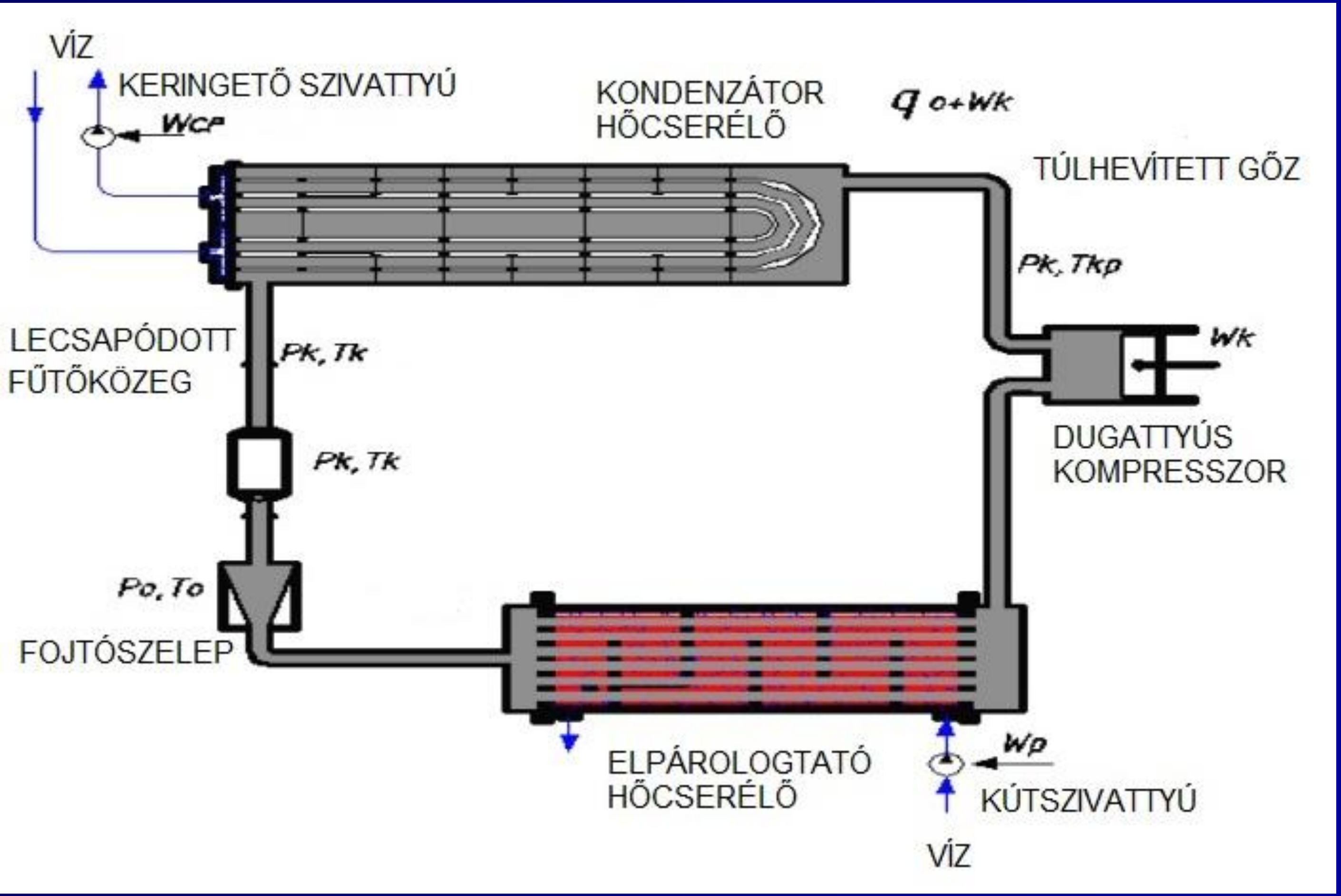
2.1 General physical model of the cooling cycle



2.1 General physical model of the cooling cycle with input and output parameters



2.2 General physical model of the water-to-water heat pump



3. Mathematical model:

- Analyzing the heat recovery system, the basic question is the energy and economic efficiency of the process. The answer can be found by determining the total and partial coefficient of performance of the system.

3.1 Heat fluxes in the recovery system:

$$\dot{q}_{rs} = \dot{q}_{ex} + \dot{q}_{1hp,c} + \dot{q}_{2hp,c}$$

3.2 Electric power demand:

$$\mathrm{P_{te} = P_{hp1} + P_{hp2} + P_{wpump1} + P_{wpump2} + P_{cpump3} + P_{cpump4}}$$

3.3 Coefficient of performance of system-COP

$$\mathrm{COP} = \frac{\dot{\mathrm{q}}_{\mathrm{rs}}}{\mathrm{P_{te}}} = \frac{\mathrm{C_{pw}} \cdot \dot{\mathrm{m}}_{\mathrm{cw}} \cdot \Delta \mathrm{T_{cw}}}{\mathrm{P_{te}}}$$

3.4 Partial COP of the individual components

Total coefficient of performance

$$COP = \frac{\dot{q}_{ex} + \dot{q}_{1hp,c} + \dot{q}_{2hp,c}}{P_{te}} = \frac{\dot{q}_{ex}}{P_{te}} + \frac{\dot{q}_{1hp,c}}{P_{te}} + \frac{\dot{q}_{2hp,c}}{P_{te}}$$

Partial coefficients of performance

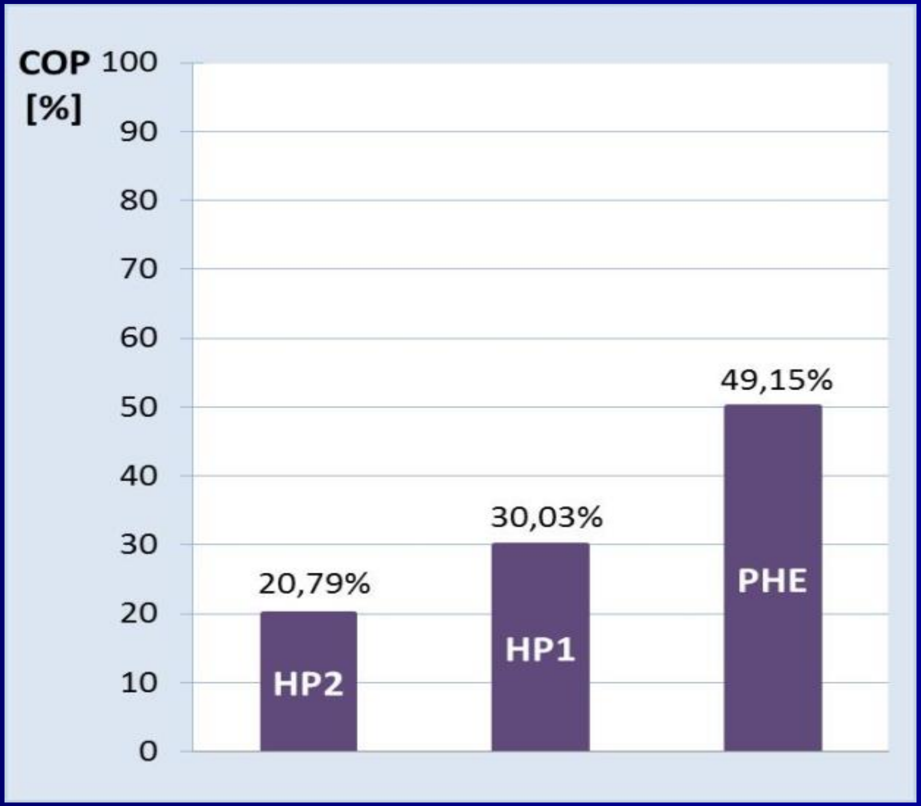
$$COP_{ex} = \frac{\dot{q}_{ex}}{P_{te}}$$

$$COP_{1hp,c} = \frac{\dot{q}_{1hp,c}}{P_{te}}$$

$$COP_{2hp,c} = \frac{\dot{q}_{2hp,c}}{P_{te}}$$

4. Case study

Measurement of the system parameters has been carried out during steady-state operation mode of the heat recovery system. All vital parameters are measured in order to determine the energy efficiency through the coefficient of performance (COP).



Thank you for your attention!

BUDAPEST, 5th. nov. 2020.

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