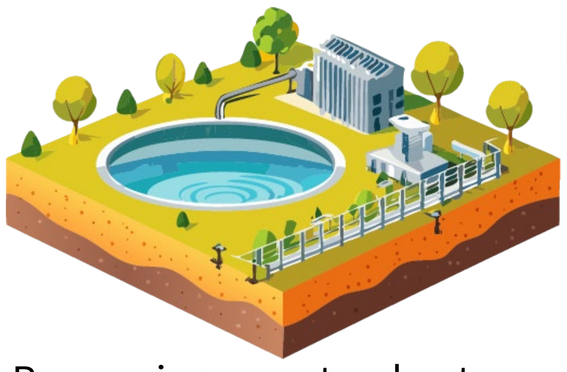
Digital Twin for Using Exhaust Heat as an Energy Source

Dr. Ievgeniia Morozova, E-Mail: ievgeniia.morozova@hshl.de, Phone: +49 2381 8789-421

Hamm-Lippstadt University of Applied Sciences, Institute for Sector Coupling in the Energy Transition, Workbench Sector Coupling

Motivation



Introduction:

- Wastewater (WW) is a safe and locally available energy source of waste heat recovery.
- Recovering waste heat energy may impede the treatment process efficiency of the WW treatment plant.
- In WW heat pumps (HP), low-potential natural heat energy is transformed into heat of a higher temperature level for use in heat supply systems.
- The transformation and conversion of these types of energy occur according to the Carnot reverse thermodynamic cycle, in which heat is transferred from a lower temperature level to a higher one, which is performed by mechanical or electrical energy supplied to the compressor.
- Systems in which WW is used with HP are referred to as wastewater heat pump (WWHP) systems.
- WWHP performance should be predicted based on inlet conditions and setpoint temperatures.
- In addition, anti-fouling technology must be integrated, or an automatic cleaning device for WWHP to extend its working cycle and prevent damage.
- **Objective of this work** is to create a digital twin of the real wastewater channel and wastewater treatment plant in combination with the desired extension – WWHP.
- This digital twin will be used to model real-time conditions and predict process performance under the specified start-up conditions and various operating regimes.
- This will help to decide which type of WWHP is suitable for the real facility, minimize risks and reduce the investment costs for the construction and commissioning of the prototype.

Methodology

P&ID of a WWHP cycle:

- WW as a thermal liquid (TL1) runs from the sewage pipe to the fixed pressure reservoir.
- The $T_{TL1'}$ flow rate, temperature and pressure are variables that are continuously controlled by a PID-controller.
- $T_{TL1'}$ is pumped into the evaporator, which evaporates the wastewater.
- In the evaporator $T_{TL1'}$ encounters the cooling agent 2P.
- The cooling agent is an environmentally friendly two-phase fluid, which is visualised as 2P in the scheme. Ammonia (R717) with a global warming potential (GWP) of 0 or propane (R290, GWP=3), or isobutane (R600a, GWP=3) can be used as working agents.
- The 2P-vapour obtained in evaporator is superheated in superheater by the reverse heat of the liquid working agent, which comes from 2P-subcooler.
- The superheated vapour is sucked into compressor, which is driven by electric motor.
- In compressor, the working agent vapour is compressed, while the vapour temperature rises.
- From compressor, 2P-vapour enters condenser (2P-TL2).
- TL2 is the water from the heating network.
- In *2P-TL2*-Condenser 2P transfers heat to TL2; at the same time, the working agent 2P condenses.
- Then the 2P-condensate is cooled in 2P-Subcooler.
- After the 2P-Subcooler, the 2P passes through the superheater which superheats the 2P-vapour coming from the evaporator into the compressor.
- 2P-vapour is throttled through throttle and converted into a 2P-liquid agent, which enters evaporator.
- Then the thermodynamic cycle of HP repeats again.

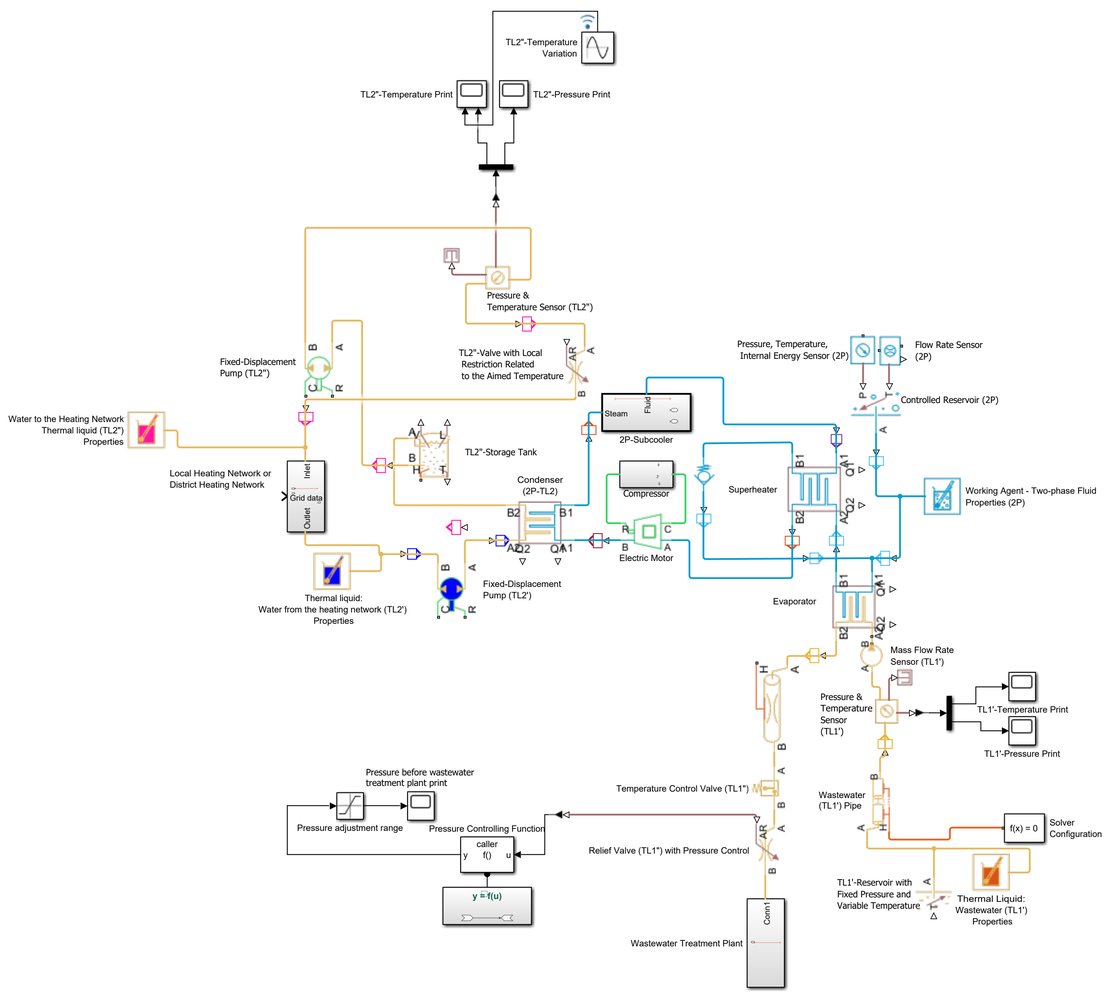


Figure. Schematic P&ID of a WWHP cycle

Outlook

- Task 1: To receive raw data from sensors & final data. Determination of actual consumption and flow rates.
- Task 2: Using the final data for modelling and pre-processing the training data.
- Task 3: Development of a predictive model. Deployment of the algorithm.
- Task 4: Time series analysis using the Kalman filter to predict a WWHP's performance.

HOCHSCHULE HAMM-LIPPSTADT

WERKBANK Sektorenkopplung

IfSK Institut für Sektorenkopplung in der Energiewende

Gefördert durch: Bundesministerium für Wirtschaft und Klimaschutz aufgrund eines Beschlusses des Deutschen Bundestages

5-StandorteProgramm

Gefördert durch: Ministerium für Wirtschaft, Industrie, Klimaschutz und Energie des Landes Nordrhein-Westfalen