Master thesis proposal:

Improving energy efficiency within Swedish industry by integration of High Temperature Heat Pumps (HTHP)

Background:

Energy efficiency is one of the most important parameters of designing energy systems. Any improvement in energy efficiency leads to lowering power usage and costs and climate change mitigation. In recent years, the European Commission emphasized the need for decarbonization of energy-intensive industries, protection from excessive price growth, and fossil fuels independence before 2030. In industry, heat represents more than 60% of energy use. Industrial heat pumps can help decarbonise low temperature heat supply within industries by using renewable energy and waste heat recovery. With today's technology, industrial heat pumps can provide about approx. 2000 TWh (10% of total final energy demand of industry) and therefore are a significant contributor to Europe's energy and climate targets. Drying processes are widely used in industry and commerce (food industry, paper industry, chemical industry, ceramics industry, etc.) and contribute significantly to energy consumption. It is estimated that 10-25% of industrial energy consumption is used for drying processes. Industrial heat pumps are defined as heat pump units with a larger capacity than 100-200kW that can provide higher temperatures than 100ºC. Industrial heat pumps possess a high integration flexibility and can utilize the available energy from different heat sources such as air, water and sewage, ground, exhaust air, solar, or waste heat from different processes. Nowadays, industrial heat pumps are mainly employed for low temperature industrial processes (temperatures below 80°C), especially in the pulp and paper, food, and chemical industrial sectors (EHPA, 2022).

The IEA Heat Pumping Technologies (HPT) Technology Collaboration Platform (TCP) has initiated IEA HPTAnnex 59 focusing on mapping the numerous possibilities and advantages of heat pump integration in drying chambers and heat treatment processes. This thesis project aims to build national knowledge on resource-efficient drying with heat pump technology and results will be used in international report. The proposed project will be used in Swedish national project to contribute to the overall aim of the IEA HPT Annex 59 in the form of a joint project with RISE, Chalmers and KTH as the executive team. The project will collect Swedish case studies focused on industrial drying, mainly in forests, pulp/paper, agriculture, food. Both state of the art and innovative solutions will be investigated and described, including needs surveys, analyses, and in-depth case studies will be analyzed from a technical, practical and financial perspective to achieve a shift towards electrified resource-efficient drying.

EHPA (2022), European heat pump market and statistics report 2022. (Report). Available online: https://www.ehpa.org/news-and-resources/publications/european-heat-pump-market-and-statistics-report-2023/

Aim:

This project will explore the opportunities to increase the efficiency, flexibility and cost-effectiveness of drying applications using high temperature heat pumps in Swedish industries.

Activities:

Conduct State of the art of drying processes and heat pumps in Sweden

- Selected at least 1-5 industrial drying processes related to one industry (forest/wood; pulp and paper; agricultural-food-dairy; chemical; polymer and plastics; pharmaceutical and construction materials) will be explored in tandem with industrial and high temperature heat pumps. The focus will be on drying processes.
- Define specifications and requirements for drying of specific products in selected industry and corresponding treatment techniques.
- Conduct techno-economic analysis to determine opportunities for heat pump-assisted drying for these processes, evaluate total costs and other critical KPI's
- Identify limitations and dimensioning criteria for a high temperature heat pump solution by analyzing different case studies and conducting interviews (if possible).
- Identify when in terms of energy saving is valid using heat pump technology.
- Analyze the results and summarize the work in report

Expected outcome

- The project will contribute to national and international report regarding the integration of high temperature heat pumps in different industrial sectors in Sweden
- Gaining knowledge about the high temperature heat pumps, industrial drying processes and integration options

Preliminary Work Plan

Week	Planned work
1-4	Literature review on relevant topic
2	Preparing and presenting a draft outline of the final report
2-13	Experimental work
4-14	Preparing and presenting the first draft of the final report
14-20	Final report preparation; presentation of final results

Starting date: January 2024

KTH Supervisors :

Monika Ignatowicz, PhD student
Applied Thermodynamics and Refrigeration Div.
Dept. of Energy Technology, Royal Institute of Technology, KTH,
Brinellvägen 68, Stockholm, 100 44, Sweden
monika.ignatowicz@energy.kth.se

EHPA (2022), European heat pump market and statistics report 2022. (Report). Available online: https://www.ehpa.org/news-and-resources/publications/european-heat-pump-market-and-statistics-report-2023/

KTH Examiner:

Rahmatollah Khodabandeh, prof.
Applied Thermodynamics and Refrigeration Div.
Dept. of Energy Technology, Royal Institute of Technology, KTH,
Brinellvägen 68, Stockholm, 100 44, Sweden
rahmatollah.khodabandeh@energy.kth.se

Project Partners:

Swedish Energy Agency, Chalmers and RISE

Number of projects:

max. 1-2 student groups, up to 8 groups

EHPA (2022), European heat pump market and statistics report 2022. (Report). Available online:
https://www.ehpa.org/news-and-resources/publications/european-heat-pump-market-and-statistics-report-2023/