Derivation of guidelines for the design of plate evaporators in heat pumps using zeotropic mixtures

The present work derives design recommendations for plate heat exchangers used for evaporation of zeotropic mixtures in heat pumps. A parametric study is conducted on the geometry of the heat exchanger, and the analysis is carried out for four working fluids, based on a case study of heat pump integration in a spray drying facility. A numerical model of the evaporator is combined with cycle calculations, for estimating the impact of heat transfer area and pressure drop on the coefficient of performance and costs. Common trends are obtained as optimal configurations for the four considered fluids. It is recommended to minimize the hydraulic diameter by employing high corrugation height over low corrugation pitch. Moreover, an optimal range is found for the liquid Reynolds number at the evaporator inlet. The suggested values vary between 500 and 2000, depending on the fluid. Lastly, the trade-off between minimization of area and pressure drop is found by assessing the relative impact on costs of the heat exchanger area and pressure losses of both working fluid and heat source. The result shows that it is not always convenient to minimize the heat transfer area, since the mixture pressure drop negatively influences compressor investment and operating costs.

High Temperature Heat Pump Integration using Zeotropic Working Fluids for Spray Drying Facilities

This paper presents an analysis of high temperature heat pumps in the industrial sector and demonstrates the approach of using zeotropic mixtures to enhance the overall efficiency. Many energy intensive processes in industry, such as drying processes, require heat at a temperature above 100 °C and show a large potential to reuse the excess heat from exhaust gases. This study analyses a heat pump application with an improved integration by choosing the working fluid as a mixture in such a way, that the temperature glide during evaporation and condensation matches the temperature glide of the heat source and sink best possibly. Therefore, a set of six common working fluids is defined and the possible binary mixtures of these fluids are analyzed. The performance of the fluids is evaluated based on the energetic performance (COP) and the economic potential (NPV). The results show that the utilization of mixtures allows a heat pump application to preheat the drying air to 120 °C with a COP of 3.04 and a NPV of 0.997 Mio. €, which could reduce the natural gas consumption by 36 %.
THERMCYC – Advanced Thermodynamic Cycles Utilizing Low Temperature Heat Sources

General information
State: Published
Organisations: Department of Mechanical Engineering, Thermal Energy
Authors: Zühlsdorf, B. (Intern), Mancini, R. (Intern), Bühler, F. (Intern), Andreasen, J. G. (Intern), Meroni, A. (Intern), Elmegaard, B. (Intern), Haglind, F. (Intern)
Number of pages: 1
Publication date: 2016
Main Research Area: Technical/natural sciences
Links:
http://www.sustain.dtu.dk/

Bibliographical note
Sustain Abstract E-25
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2016

Projects:

Heat transfer equipment for utilization of low temperature heat sources
Department of Mechanical Engineering
Period: 01/12/2015 → 30/11/2018
Number of participants: 4
Phd Student:
Mancini, Roberta (Intern)
Supervisor:
Haglind, Fredrik (Intern)
Markussen, Wiebke Brix (Intern)
Main Supervisor:
Elmegaard, Brian (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD