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Performance analysis of an absorption heat transformer with different working fluid combinations

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Abstract

The absorption heat transformer (AHT) is a promising system for recovering waste heat. It can effectively recover about 50% of the waste heat and reuse it in industrial processes. However, there exists a need for identifying suitable working fluid combinations and for evaluating their relative performance characteristics. As an initial step, this paper presents a comparative performance study for the absorption heat transformer with H_2O/LiBr, TFE(2,2,2-trifluoroethanol)/NMP(*N*-methy1-2-pyrrolidone), TFE/E181(dimethylether tetra-ethylene glycol) and TFE/PYR(2-pyrrolidone). The results show that the four working fluid combinations are all suitable for absorption heat transformers. H_2O/LiBr is suitable at lower operating temperatures, while TFE/NMP, TFE/E181 and TFE/PYR are suitable at higher operating temperatures.

Keywords: Absorption heat transformer; H_2O/LiBr; TFE/NMP; TFE/E181; TFE/PYR

1. Introduction

In recent years, large quantities of heat from industries have been rejected to the atmosphere as waste water or waste steam which not only wastes energy but also pollutes the atmosphere. The absorption heat transformer can effectively recover about 50% of the waste heat and reuse it in industrial processes [1].

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Nomenclature

COP	coefficient of performance
COP_{rev}	Carnot coefficient of performance
dx	concentration differentials (kg kg^{-1})
E181	dimethylether tetraethylene glycol
GTL	gross temperature lift (°C)
h	enthalpy (J kg^{-1})
$\dot{m}$	mass flow (kg s^{-1})
NMP	*N*-methy1-2-pyrrolidone
PYR	2-pyrrolidone
Q	heat flow (kW)
T	temperature (°C or K)
TFE	2,2,2-trifluoroethanol
x	salt mass fraction (kg kg^{-1})
η_{ex}	exergy efficiency
φ	economizer effectiveness

Subscripts

AB	absorber
CO	condenser
EV	evaporator
GE	generator
SO	heat source
o	output
i	input
1…10	refer to state points of the cycle shown in Fig. 1

Even though the absorption heat transformer has been reported to be a promising candidate for boosting the thermal level of waste heat sources, suitable working fluid combinations need to be identified and their relative performance characteristics need to be evaluated. A comparative thermodynamic analysis is the initial step. Such a study is presented here using H_2O/LiBr, TFE(2,2,2-trifluoroethanol)/NMP(*N*-methy1-2-pyrrolidone), TFE/E181(dimethylether tetraethylene glycol) and TFE/PYR(2-pyrrolidone) as the working fluid combinations. The main advantages of H_2O/LiBr are: high enthalpy of evaporation, high heat and mass transfer, non-toxicity, no need for rectification apparatus, etc. The main disadvantages are its corrosiveness and crystallization at high temperatures. The main advantages of TFE/NMP, TFE/E181 and TFE/PYR are: high thermal stability, high output heat temperature, flat vapor pressure curve and strong negative deviation from Raoult's law. The main disadvantages are their toxicity, since they all have the same toxicity as ammonia.