Applied Thermal Engineering 42 (2012) 2–5

Contents lists available at ScienceDirect

Applied Thermal Engineering

journal homepage: www.elsevier.com/locate/apthermeng

Performance of a triple-pressure level absorption/compression cycle

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ARTICLE INFO

Article history:
Received 1 July 2010
Accepted 7 January 2011
Available online 1 February 2011

Keywords:
Triple-pressure level absorption cycle
Absorption cycle
Cycle analysis
COP

ABSTRACT

The performance of the triple-pressure level (TPL) single-stage absorption cycle operated with various organic refrigerants and absorbents showed many advantages over the common double-pressure level (DPL) absorption cycle. In order to enhance these advantages (increased COP and decreased generator temperature); the jet ejector was replaced by a mechanical compressor and a mixing device. In the modified triple-pressure level absorption cycle, the compressor was inserted in the super heated refrigerant line between the evaporator and the absorber. The influence of the elevated pressure on the performance of the TPL absorption cycle with the working fluid pentafluoroethane (R125) and N,N′-dimethylethylenurea (DMEU) was predicted by a computerized simulation program. The performances of the TPL absorption cycle operated with mechanical compressor or jet ejector and the DPL absorption cycle were compared. Based on the analysis the following advantages were achieved: a significant reduction of the required generator temperature (i.e., ability to use low grade heat source such as solar energy), increased coefficient of performance (COP), reduction in the circulation ratio (*f*) and the reduction of the actual size of the solution heat exchanger. The disadvantage of inserting the compressor is increased electricity consumption.

1. Introduction

Utilization of low-potential heat sources (70–120 °C) for cooling and refrigeration (below 0 °C) can be implemented in a conventional double-pressure level (DPL) single-stage absorption cycle. The common working fluids such as ammonia–water or water–lithium bromide are limited to match these conditions [1,2]. To overcome these limitations, the working fluids based on fluorocarbon (HFC) refrigerants and organic absorbents can be used [3–8]. The refrigerants are not toxic or corrosive and the organic working fluids are environmentally acceptable. The performance of these working fluids in a conventional double-pressure level (DPL) single-stage absorption cycle are expressed in terms of coefficient of performance (COP)[1] in the range of 0.5–0.6 and a circulation ratio (*f*)[2] in the range of 3–7. In order to improve these performances various configurations of absorption cycles have been suggested by adding a jet ejector at the absorber inlet as a device for mixing and pressure recovery [9–14]. These cycles are triple-pressure level (TPL) single-stage absorption cycles.

Jelinek et al. [12], studied the influence of the pressure recovery by the jet ejector on the performances of the TPL absorption cycle (in comparison with the DPL) in four separate cases where one operating condition in the TPL was varied and all the other conditions remained the same for both types of the cycle. Jelinek et al. concluded that these improvements can be implemented by decreasing the circulation ratio *f* (Case 1) or by changing the governing cycle temperatures as follows: lowering the refrigeration temperature, i.e., the evaporator temperature Te (Case 2); lowering the heat source temperature, i.e., the generator temperature Tg (Case 3); or raising the cooling water temperature, i.e., the condenser and absorber temperature Tw (Case 4).

The performance of a single-stage triple-pressure level (TPL) absorption cycle with different refrigerant-absorbent pairs was investigated by Jelinek et al. (2008). Four HFC refrigerants namely: difluoromethane (R32), pentafluoroethane (R125), 1,1,1,2-tetrafluoroethane (R134a), and 1,1-difluoroethane (R152a) which are alternative to HCFC, such as chlorodifluoromethane (R22) and 2,-chloro-1,1,1,2-tetrafluoroethane (R124), in combination with the absorbent dimethylethyleneurea (DMEU) were considered. The highest coefficient of performance (COP) and the lowest circulation ratio (*f*) were found as a function of the generator temperature for a given evaporating and cooling water temperatures. The sensitivity of the COP and *f* for evaporator and cooling water temperatures changes at the maximum COP for the best

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[1] Defined as the heat rejected from the evaporator divided by the sum of the heat supplied to the generator and the energy supplied to the pump or/and compressor.

[2] Defined as the mass flow rate of the solution at the pump inlet divided by the mass flow rate of the refrigerant at the condenser inlet.

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doi:10.1016/j.applthermaleng.2011.01.011