Accepted Manuscript

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PII: S0140-7007(16)30418-2
DOI: http://dx.doi.org/doi: 10.1016/j.ijrefrig.2016.12.006
Reference: JIJR 3498

To appear in: *International Journal of Refrigeration*

Received date: 11-7-2016
Revised date: 8-11-2016
Accepted date: 12-12-2016

Simulation of an Ammonia–Water Heat Pump Water Heater with Combustion Products-Driven Evaporator

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Highlights

- Ammonia-water heaters can reach a COP of 1.47.
- A purification column for variable seasonal conditions is simulated.
- A new evaporator design promises smaller heat transfer area and fan power.
- Subcooling in the condenser eliminates the precooler.
- Subcooling of the pump inlet would result in a compact heater.

Abstract

The objective of this work is to simulate a single effect (SE) ammonia-water heat pump for domestic water heating, with innovative aspects for cycle simulation and eventual practical implementation. The following practical difficulties are addressed in the simulation: 1. seasonal temperature variations change the operating conditions of the distillation column, calling for insightful design to maintain a suitable refrigerant concentration in all seasons, and particularly in winter; 2. The evaporator activated by outdoor air suffers from immoderate heat transfer requirements, and these demands are considerably reduced if the activation is done by products of combustion; 3. Pumps have head requirements that can be assuaged by judicious selection and inlet solution subcooling. The variables that need to be controlled if the same column is to be used all year round are specified. As configured with the innovations mentioned, the cycle simulation yields a coefficient of performance within the expected range for a single effect, but it harbors the promise of a much smaller evaporator, of small overall height, and of a distillation column capable of operating effectively all year round with the same feed point.

Keywords: absorption; ammonia-water; heat pump; water-heater; distillation; domestic water

Nomenclature

A	Heat transfer area, m^2.
cp	Combustion products.
COP	Coefficient of performance.
CPAE	Combustion products assisted evaporator.
f	Fuel to air mass ratio.
g	Gaseous combustion products.
GAX	Generator absorber heat exchange.
h	Specific enthalpy, kJ kg^{-1}.
H_a	Absolute pressure equivalent head, m.
H_f	Head loss in feed pipe to pump, m.