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Development and performances overview of ammonia-water absorption chillers with cooling capacities from 5 to 100 kW

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Abstract

From 2010 to 2015, three similarly design based absorption chillers have been developed, manufactured and characterized on test benches. The chillers are all ammonia-water thermally driven single effect chiller. They are intended to operate using directly solar thermal energy or using waste heat from Concentrated Solar Plant (CSP). The first one is a laboratory prototype, fully instrumented with a cooling capacity of 5 kW. The second one is a pre-industrial version of the first prototype with the same cooling capacity but less instrumented and with a compact design. The last development is a 100 kW cooling capacity chiller, with technical choices between the two first prototypes, but design to provide cooling effect at temperatures suitable from air-conditioning to ice making. In this paper, the design principles and the technological choices made for each chiller are described and a comparison of the experimental results is done.

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Keywords: absorption chiller; ammonia-water; thermally driven; design; experimental results

1. Introduction

From more than fifteen years, the development of air-conditioning offers more and more comfort to people. Major part of commercial air-conditioners uses electricity-powered vapor compression machines to provide the frigorific effect. The use of that technology must face to a paradox: more the number of air-conditioners installed in

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a city increases, more heat released to urban atmosphere rises, thus increasing the ambient air temperature which implies a decreasing the performance of the chiller and increasing the cooling load of buildings [1]. In fine, peak electricity demand for cooling can be tripled [2].

One of the solution could be the use of thermally driven chillers powered by waste-heat or solar energy. Among the two main working pairs for absorption chillers, ammonia-water chillers are particularly interesting because of their low production and maintenance costs [3]. Moreover, the high pressure thermodynamic cycle performed with that couple is favorable to optimize the internal heat and mass transfers, to reduce the fluid charge, to limit the effect of the hydraulic pressure drops, thus helping to reach a compact machine design [4].

The ammonia-water absorption chillers described in this paper was especially designed in that way.

Nomenclature

Variables

A	Surface	[m^2]
COP	Coefficient of performances	[-]
M	Masse flow rate	[$kg.h^{-1}$]
P	Thermal power	[kW]
T	Temperature	[°C]
ΔT	Temperature difference	[°C]
U	Global heat transfer coefficient	[$W.m^{-2}.K^{-1}$]
X	Mass fraction	[-]
η	Effectiveness	[-]

Subscripts

A	Absorber
AC	Absorber-Condenser
C	Condenser
E	Evaporator
G	Generator
htf	Heat transfer fluid
in	Inlet
out	Outlet
ps	Poor solution
R	Rectifier
ref	Refrigerant
rs	Rich solution
sat	saturated
th	Thermal
wf	Working fluid

2. Methodology and development principles

The three prototypes of ammonia-water absorption chiller have been designed and built between 2010 and 2015: the first one is a laboratory test bench, fully instrumented with a cooling capacity of 5 kW. The second one is a pre-industrial version of the first prototype with the same cooling capacity but less instrumented and with a more compact design. The last development is a 100 kW cooling capacity chiller connected to an experimental Concentration Solar Plant (CSP) and design to provide cooling effect at temperatures suitable from air-conditioning to ice making.