Applied Energy 130 (2014) 51–71

Contents lists available at ScienceDirect

Applied Energy

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

Absorption heating technologies: A review and perspective

Wei Wu, Baolong Wang, Wenxing Shi, Xianting Li *

Department of Building Science, School of Architecture, Tsinghua University, Beijing 100084, China

HIGHLIGHTS

- Classifications and principles of various absorption heating cycles are presented.
- Applications and studies in civil, industrial and rural fields are reviewed.
- Summaries and suggestions are presented to extend absorption heating technologies.

ARTICLE INFO

Article history:
Received 27 March 2014
Received in revised form 6 May 2014
Accepted 14 May 2014

Keywords:
Absorption heating
Absorption heat pump
Heat supply
Temperature upgrading
Industrial energy efficiency
Rural energy efficiency

ABSTRACT

Absorption heating has attracted increased attention due to its irreplaceable advantages in energy conservation and pollution reduction in heating and domestic hot water supplies. This paper presents the classifications and principles of different absorption heating cycles and comprehensively reviews their statuses and development in different application fields. Civil applications include direct-fired chiller/heaters, fuel-driven absorption heat pump water heaters, the latent heat recovery of vapors, hybrid compression–absorption heating, solar-assisted absorption heat pumps, absorption-based district heating, thermal energy storage and transportation, ground source absorption heat pumps and thermal imbalances in cold regions. Industrial applications include absorption-assisted drying, absorption-assisted evaporation, absorption-assisted distillation, and absorption-assisted waste heat recovery. Additionally, several rural application concepts are also provided. Based on the reviews, essential summaries and suggestions are presented, which are expected to extend the absorption heating technologies for additional contributions to energy conservation and environmental protection.

Contents

* Corresponding author. Tel.: +86 10 62785860; fax: +86 10 62773461.
E-mail address: xtingli@tsinghua.edu.cn (X. Li).

http://dx.doi.org/10.1016/j.apenergy.2014.05.027
0306-2619/

Nomenclature

AHE	absorption heat exchanger	ECOP	exergy coefficient of performance
AHP	absorption heat pump	GAX	generator absorber heat exchange
AHS	absorption heat storage system	GSHP	ground source heat pump
AHT	absorption heat transformer	GSAHP	ground source absorption heat pump
AHTR	absorption heat transportation	GSEHP	ground source electrical heat pump
ASAHP	air-source absorption heat pump	GUE	gas utilization efficiency
CAHP	compression–absorption heat pump	HAT	humid air turbine
CCHP	combined cooling, heating and power	LHX	liquid heat exchange
CHP	combined heating and power	OAHP	open-cycle absorption heat pump
COP	coefficient of performance	OAHT	open-cycle absorption heat transformer
DHW	domestic hot water	PEE	primary energy efficiency

1. Introduction

Recent decades have witnessed an increasing worldwide popularity of absorption chillers and heat pumps due to their irreplaceable advantages in renewable energy utilization and waste heat recovery. With ever-growing efforts on energy conservation and emission reductions, absorption technologies play a significant role in global energy and environmental issues.

Absorption cycles generally use natural fluids (such as H_2O–LiBr and NH_3–H_2O) as working pairs, which do not contribute to global warming or ozone depletion [1]. Absorption cycles are attractive options for solar cooling, while gas-fired absorption cooling is a good alternative for peak-load shifting. Moreover, the ability for low-grade heat utilization makes absorption systems attractive in geothermal cooling, waste heat cooling and combined cooling, heating and power (CCHP) systems [2,3].

The majority of studies on absorption technologies have focused on cooling and refrigeration applications. Recently, absorption heating has received increased attention due to its advantages in improving the efficiency of existing heating and domestic hot water systems [4,5]. The nationwide issue of smog and haze in China highlights the urgency to innovate and upgrade heating systems in northern China to systems that require less coal and reduce pollutant emission. Additionally, heat supply systems in rural areas and industrial processes should also be modified for better performance. This paper reviews the status and development of absorption heating technologies used for civil, industrial and rural applications. The classifications and principles of different absorption heating cycles, and essential summaries and suggestions are presented, which are expected to extend absorption heating technologies to contribute to energy conservation and environmental protection practices.

2. Description of various absorption heating technologies

2.1. Classifications of absorption heating

The classifications of various absorption heating technologies are shown in Fig. 1. According to the characteristics of heat quantity change or temperature change, absorption heating can be classified into 4 categories: (1) heat increasing, to output more heat energy than the supplied heat source (i.e., heat multiplier); (2) heat shifting, to transfer the available heat from the present time to a future time (i.e., absorption heat storage) or from one place to another (i.e., absorption heat transportation); (3) temperature upgrading, to export a hot stream with a higher temperature than the input stream; (4) temperature adapting, to adapt the fluid temperature like an electrical adapter. An absorption heat exchanger is a type of temperature adapting system, and can overcome the limitations of traditional heat exchangers.

For each type of absorption heating system, there are various absorption cycles for different conditions. For example, in an absorption heat pump (AHP), singe-effect is the basic cycle used under normal conditions, whereas a multi-stage, compression-assisted and coupled cycle can be used under lower evaporation temperatures, higher condensation and absorption temperatures or lower generation temperatures [6,7]. Additionally, a multi-effect and a generator absorber heat exchange (GAX) cycle can be used to achieve higher efficiency [8], and an open-cycle can be used for the recovery of the latent heat in the vapor.