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Liquid absorption and solid adsorption system for household, industrial and automobile applications: A review

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ABSTRACT

The degradation of fossil fuels and other non-renewable energy resources are the challenges faced by current and future generations. This trend requires humans to utilize, reuse, and transform energy efficiently, for the right applications and with the right timing. The low-grade heat from industry, automobiles and the sun could be used/reused to drive a liquid absorption system and solid adsorption system. Then, the absorption and adsorption system could provide refrigeration, dehumidification and heating owing to the proper utilization of low-grade heat at 60–90 °C. The reuse of low-grade heat would reduce the heat pollution to the environment and avoid/minimize the consumption of fossil energy to drive the absorption and adsorption system. In this paper, the absorption and adsorption system are differentiated and categorized by the source of heat energy and its applications. The three main topics discussed are absorption, adsorption, and dehumidification. The individual working mechanism of each absorption and adsorption system is described thoroughly. This paper provides insights into innovative ways for how these systems could be constructed.

Contents

1. Introduction

The main differences between absorption and adsorption are the materials, substance state and circuit layout. In absorption, a base solution dilutes the refrigerant vapor and becomes a weaken solution. The base solution is regenerated by evaporating the refrigerant from the base solution. In adsorption, the refrigerant is adsorbed and refrigerant stays on the surface of the solid-grain adsorber upon cooling. During desorption, the refrigerant evaporates from the solid adsorber material upon heating. For absorption, the adsorber and generator are two different compartments, between which a heat exchanger is always installed. For adsorption, both adsorption and

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desorption share the same adsorber beds. The adsorber beds are heated and cooled in alternative sequence. The similarity between absorption and adsorption is the two-compartment condenser and evaporator. The condenser will condense the refrigerant vapor evaporated during the desorption/regeneration process. The evaporator will evaporate the refrigerant (thus provide cooling effect), and prepare the refrigerant vapor for the adsorption process.

The function of absorption and adsorption system is mainly to provide refrigeration, heat up cold water, and dehumidification. The liquid absorption and solid adsorption system could dehumidify the air when the pairing refrigerant for the system is water vapor in humid air. Sometimes, the same system could provide a cooling effect and dehumidification, as well as heat up cool water.

Both the absorption and adsorption system could reuse the low-grade heat (80–150 °C), such as waste heat from industry, and automobile and solar energy. This would help to reduce the global warming effect by reducing the direct emission of hot gases/air from industry/automobile into the atmosphere. Furthermore, the heat is reused to drive air-conditioning and refrigeration, instead of using electricity or natural resources.

When the heat energy is utilized wisely, it is absorbed from wherever heat is not desired, and pumped to wherever heat is required. The waste heat from industry, households and automobiles can be recycled for absorption refrigeration, adsorption refrigeration, and dehumidification purposes. Renewable energy, such as solar energy, could also drive absorption and adsorption refrigeration systems. This would reduce global dependence on non-renewable energies, such as petroleum and natural gas.

There are several review paper written on absorption, adsorption, and dehumidification. However, there are limited papers which reviewed all three topics concurrently, and categorized them according to different heat sources and applications. When absorption, adsorption and dehumidification are studied together, it will prevent confusion among the systems, and all the system will be defined clearly and precisely.

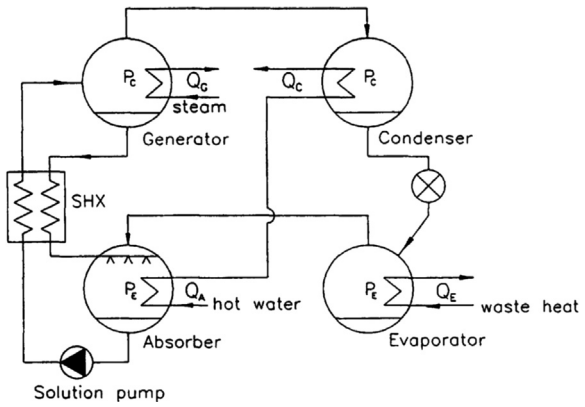

Fig. 1. General layout of absorption system [1].

2. Absorption

In an absorption system, there is one loop for strong solutions and weak solutions (after the refrigerant is diluted in the base solution). There is another loop solely for refrigerant. The strong solution becomes a weak solution after it absorbs the refrigerant from the evaporator. The weak solution becomes a strong solution after it evaporates the refrigerant from base solution and condenses in condenser, after being heated up in a generator. Fig. 1 displays the general layout of an absorption system. Normally, waste heat emitted by industry and automobiles, or from other renewable energy (low-grade heat source), is utilized to operate the generator. Cool water is pumped to cool down the absorber and the condenser (in other words, the adsorber and condenser heat up cool water for household usage). Lastly, the evaporator absorbs unwanted heat to make the absorption cycle function well (evaporator provides chilling effect). In short, a heat pump delivers heat to wherever it is required, and absorbs heat from wherever it is not required.

2.1. Absorption system driven by industrial waste heat

In an absorption system, waste heat and renewable energy could drive the generator, and provide a cooling effect in an

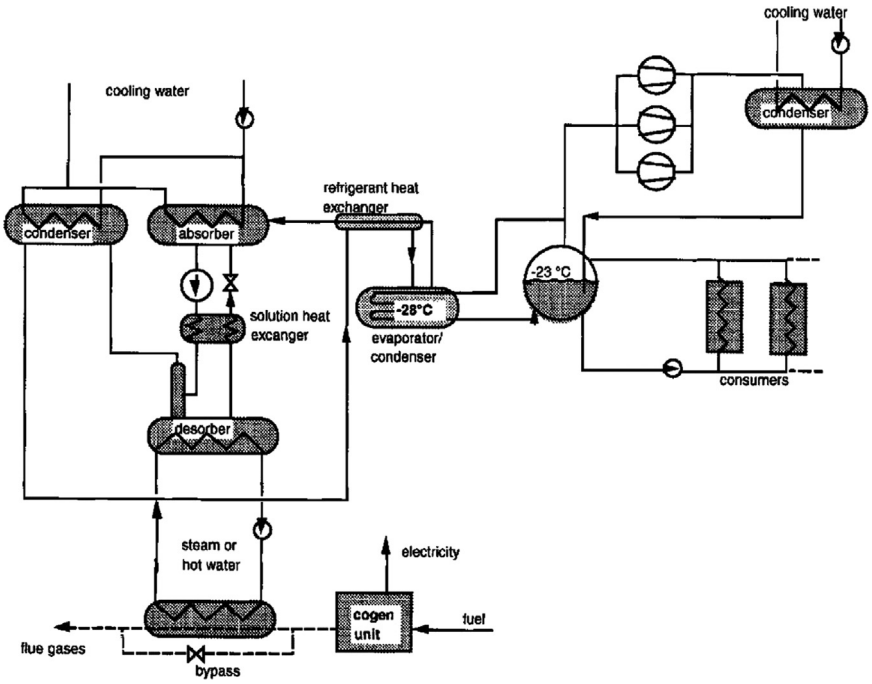

Fig. 2. Combination of am absorption refrigeration plant (ARP) and a compression refrigeration plant [3].