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Review On Adsorption Refrigeration System

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Abstract : *"Energy can neither be created nor be destroyed"- first law of thermodynamics. the energy potential of the world is constant , so we have to save the energy as much as possible .as the refrigeration is needed everywhere in the world and it is the major user of energy. The energy that could be used for the adsorption refrigeration is powered by low grade heat. the low grade heat can be obtain from industrial waste heat, exhaust gases from the engines or heat from solar thermal collector. Moreover it uses environment kindly refrigerants and avoids the global warming and ozone depletion..*
Keywords: *Adsorption, adsorption system working pairs, waste heat.*

I. Introduction

Everywhere in our world, refrigeration is a major energy user. In poor areas off grid refrigeration is a critically important need. Refrigeration is an interesting application of solar energy because the incident radiation and the need for cold production both reach maximum levels in the same period. all of these considerations point the way toward refrigeration using renewable energy, as part of a sustainable way of life. Solar-powered refrigeration is a real and exciting possibility. Due to the increasing concentration of green house gases and climate changes, the need for renewable energy sources is greater than ever. This has now attracted attention from the countries that has set up targets to increase the share of renewable energy supply in the world in order to reduce greenhouse gas emissions.

Nomenclature

GHG	Green house gases
CCHP	combine cooling and heating
SCP	Specific Cooling Power
COP	coefficient of performance
GDP	global warming potential
h_{fg}	latent heat of vaporization

II. Sorption Refrigeration Cycle

The sorption refrigeration cycle is a thermodynamic cycle with two sources and two sinks, which operates using three temperature levels. Two of them are used to drive the thermal compressor "Reactor" that replaces the mechanical compressor in a vapour compression refrigeration cycle, The sorption refrigeration cycle operates between two pressures and two refrigerant / sorbent concentration levels.[1]

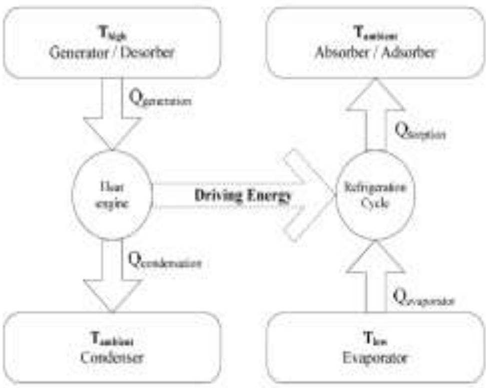

Figure 1 sorption cycle

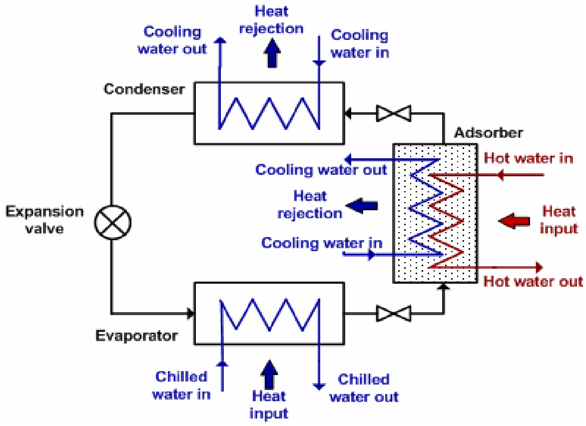

Figure 2 Simple Adsorption cooling system

Simple adsorption refrigeration system consist of a generator that is the adsorption bed which is nothing but a heat exchanger having the adsorbent such as silica gel activated carbon , zeolite etc. Material sticking on the outer side of heat exchanger tubes and fins which increases the rate of heat transfer. It also consist of the evaporator condenser expansion device similar to an conventional VCRS. The solid adsorber adsorbs the refrigerant vapour when the cooling fluid is passed through the adsorption bed. These are the vapours of refrigerant that are form by taking the heat load from the evaporator and produce the cooling effect in the evaporator. After the adsorption of vapours in next phase of cycle the hot fluid is again send to the adsorption bed which creates the desorption of vapours which are passed through the expansion device through the condenser and then to the evaporator and the cycle can be repeated.

III. Working Pairs

Working pairs are essential and critical in adsorption refrigeration system. The requirement for appropriate working pairs and status of current research into this topic were reviewed by Wang et al. (2009).Two aspects was reviewed: firstly, refrigeration performance requirements; and secondly, basic natural property requirements. In regard to the formed requirements, a refrigerant should have large latent heat of vaporization and little adsorption heat so that a high COP can be achieved, while an adsorbent should have significant and varied adsorption capacity that corresponds with temperature change, in order to generate high specific cooling power (SCP). Ideally with regard to requirements for natural properties, being environmental friendly, appropriate working pressure and temperature, and having thermal stability are aimed for.[2]

In investigations of common working pairs, numerous adsorbent/adsorbate combinations have been applied and compared. Most research has been done using activated carbon/methanol, activated carbon/ammonia, zeolite/water, silica gel/methanol, silica gel/water as working as working pairs. Various comparative studies were conducted by Critoph (1988), San and Lin (2008) and Wang et al.(2009).

According to these comparative studies, activated carbon/methanol an silica gel/water have been recognized as two appropriate working pairs in the application of a low temperature driven system, because both of these two working pairs can normally be driven by a low temperature heat source (below 100^{o} C), while a working pair with zeolite normally needs the temperature of heat source to be 200^{o} C. Some physical methods were employed to improve and change the working pairs properties so they worked better. Tamainot-Telto and Critoph (2000) investigated the thermo physical properties of monolithic carbon that is manufactured by compressing and firing solid carbon with an organic binder. Three critical parameters of the monolithic carbon were significantly improved: max concentration increased from 0.29 to 0.36 kg/kg; thermal conductivity rose from 0.16 to 0.60 W/mk; and density increased by 50% to 750 kg/m^3. Research into composite working pairs mainly focuses on improving thermal conductivity and enhancing the adsorption capacity of adsorbents. Currently, there are two main ways to produce composite adsorbents, namely simple mixture and impregnation.[2]

The first method is simply the process of mixing the chemical adsorbent and porous physical adsorbent. The chemical adsorbent is applied as an impregnated salt while the physical adsorbent is added as a host matrix to form an internal porous structure and enhance thermal conductivity.

The second method is known as impregnation in which a compound adsorbent is extracted from a mixed solution, whereby both the physical adsorbent (additive) and

Chemical adsorbent are dissolved and mixed in a solution. In order to further increase the thermal conductivity and physical density, a composite adsorbent that is made using the above two methods can be compressed to form adsorbent blocks, known collectively as solidified composite adsorbent. Some of the working pairs are shown in table below.[2]

Table 1 The working pairs in adsorption refrigeration

Adsorbent	Adsorbate(refrigerant)
Activated carbon Activated carbonfiber Silica-gel Zeolite	Water Ammonia Ethanol Hydrogen, methanol

IV. Development In The Adsorption System

Adsorption system are invented with different focus , for one bed machine , simple structure and low cost are pursued it can be used in applications when continuous cooling or higher cooling capacity is not required ,such as cooling drinks, storage of vaccine. Multi-bed systems are suggested to provide steady refrigeration and higher energy performance .in order to increase system COP and SCP . It is the object of several inventions to provide an improved sorption cooling system for use in various applications which are not limited by the desorption efficiency of the adsorbent. Methods are sought which provide low cost heat recovery with sorption cooling systems integrated in such a manner to provide an overall stable , continuous operation . Three main technologies to improve the process have been extensively developed: regenerative processes with temperature front (also named thermal wave process)-heat transfer fluid is circulated through the system by a reversible pumping means , the beds are cycled between an upper and lower operating temperature, creating the thermal wave within the bed of solid adsorbent. [5]

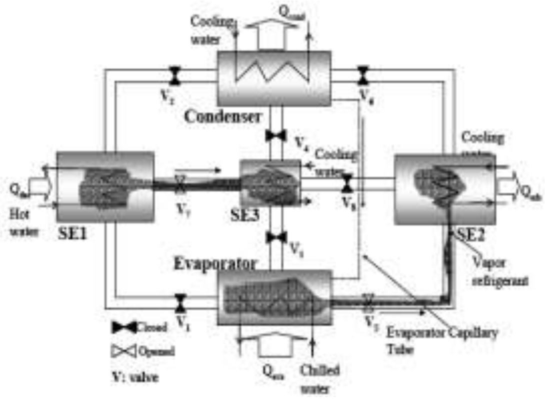

Figure 3 three bed chiller with mass recovery

The system includes a condenser , an evaporator and number of reactor, each being able to operate in adsorption and desorption modes and having a coolant inlet to directly or indirectly receive coolant when operating in adsorption mode before after or simultaneous with the condenser. A waste heat inlet for directly or indirectly receive thermal energy from a waste heat source when operating in desorption mode. Each adsorber alternately operates in adsorption and desorption modes for substantially identical time intervals. Each adsorber has an equal chance of being first adsorber to receive the coolant when operating in adsorption mode, and the waste heat from the waste heat source when operating in desorption mode.

Third technology involving rotating adsorbers-rotary structure has been used for heat regeneration in adsorption system and provides continuous cooling effect. A rotary thermal regenerative adsorption system which has a number of adsorption module circumferentially about a rotary axis partly within toroidal conduit. A heat transfer fluid flows from an inlet of the conduit to the outlet in counter flow with respect to the rotational movement of the adsorbent modules. Separate fluid channels encase the evaporation /condensation zones of the vessels to enable transfer of heat between the vessels and the fluid flowing in channels. In this system heat is generated in particularly simple and convenient manner. As a result the compressive device is capable of achieving higher efficiencies than existing adsorption devices. [5]

V. Heat Pipe Technology

There are three vacuum chambers in this type of adsorption chiller two adsorption or desorption (or evaporation or condensation) vacuum chambers and one heat pipe working vacuum chambers as the evaporator. One adsorber, one condenser and one evaporator are housed in the same chamber to constitute an adsorption or desorption unit. The evaporators of two adsorption or desorption units are combined together by a heat pipe heat exchanger to obtain continuous cooling effect

VI. Conclusion

The technologies for adsorption refrigeration have been extensively studied in academic as well an industry. For adsorption refrigeration system, significant achievement have been obtained on the use of various technologies to reduce the complexity of system structure, initial cost, to increase the system operation reliability as well as energy performance. Use of the solar energy in the adsorption system is a great alternative as the system is compatible with low grade heat energy. Nearly all waste heat resources can be coupled up with the adsorption refrigeration system to get a refrigeration effect. Incorporation of the consolidate adsorbents, coated adsorbents and improvement in the heat transfer process make the adsorption system an great alternative to the future refrigeration need

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