Advanced Adsorption Chiller Driven by Low Temperature Heat Source

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Abstract:

Most of the refrigeration and heat pump technologies are dominated by vapor compressor system. However, the vapor compressor system is highly concerned with the environmental regulations, as most of the vapor compressor technologies are using HFCs and HCFCs which are known as ozone depleting and global warming gases. Moreover, the increase uses of the vapor compressor driven refrigeration devices can make us more dependency on the primary energy resources . In contrast, it is necessary to reduce the primary energy consumption and to introduce renewable energy for the sustainable development in the global energy sector. Therefore, refrigeration technologists are extremely investigating to originate or to develop an alternative to vapor compressor refrigeration devices. Thermally driven, sorption technology is one of the possible alternatives. In the moment, absorption (liquid vapor) cycle is most promising technology. However, the adsorption (solid vapor) cycle have a distinct advantage over other systems in their ability to be driven by heat of relatively low, near-environmental temperatures, so that heat source (waste or solar heat) below 100 ºC can be recovered, which is highly desirable.

Silica gel/water conventional adsorption chiller can be driven successfully with 80 ^{0}C heat source temperature with cooling source temperature 30°C. However, heat utilization near environmental temperatures still facing technical hurdles. A two-stage silica gel-water adsorption refrigeration cycle can exploit the heat source of temperature around 60°C with the cooling source at 30°C. The coefficient of performance (COP) of a two-stage adsorption refrigeration cycle, however, is quiet low. Moreover, both the COP and cooling capacity of a two-stage chiller are extremely sensitive to the driving heat source temperature. From this context, a novel adsorption refrigeration cycle is proposed in the study. The proposed system is able to exploit the heat source of temperature 50-90°and can produce the cooling effectively.

In the study, a design strategy and the mathematical model of our novel system are presented and the performance is evaluated numerically. Results show that the proposed system provides more than 100% cooling capacity than the conventional system if the heat source temperature is below 60°C. The proposed chiller also provides almost same cooling capacity comparing with two-stage chiller for the low temperature heat source, while it provides nearly 30% more COP value than the COP value provided by two-stage chiller. Simulation results also show that the overall performance of the proposed system is always higher than that of conventional and two-stage adsorption cycle even the temperature of the heat source is fluctuated in the range 50-90°C. Therefore, it can be clamed that the proposed system can utilize solar heat effectively. The system also provides the almost uniform temperature chilled water outlet, which is very important in hot and humid climate.

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