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Comparative analysis of performance and techno-economics for a H_2O–NH_3–H_2 absorption refrigerator driven by different energy sources

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ABSTRACT

The objectives of the present work are of two-folds. First, it evaluates the transient temperature performance of the H_2O–NH_3–H_2 absorption cooling machine system's components under two types of energy sources, i.e. the conventional electric energy from grid (electric) and fuel energy from liquid petroleum gas (LPG). Results obtained have shown that performance of various components under different type of energy sources is almost coherent. For the evaporator, the system with electric supply has shorter starting time, around 6 min earlier than the system run with LPG. Meanwhile, the system powered by LPG produced a lower cooling temperature around −9 °C, compared to the system run with electric which produced temperature at around −7 °C. Economical study had been carried out subsequently, for three different energy sources, i.e. electric, LPG and solar energy (photovoltaic). From the techno-economical analyzes, it was found that the conventional electric from grid is still the best form of energy source for short-term application, as far as the present location and conditions are concerned. LPG is the next attractive energy source, especially at locations with constant LPG supply; the photovoltaic energy from solar is attractive for long term consideration since it has zero fuel cost and environmentally-friendly, but with the highest initial cost.

1. Introduction

Energy sources, system performance and economics are all interrelated and very much dependent in an energy-dependant system, such as that of air-conditioning system. The use of air-conditioning technology for cooling is not new; however, air-conditioning technology is required to evolve due to many environmental regulations, such as Montreal protocol in 1987, Kyoto Protocol and European Commission Regulation 2037/2000. These regulations or policy instruments are concerning the depletion of the ozone layer and global warming, which decided to phase-out CFCs and to be followed by HCFCs in conventional compression air-conditioning. As a result, this has lead to a strong demand for alternative air-conditioning technology. Absorption refrigeration is one of the alternative technologies that uses heat energy to produce desired cooling; as compared to the common refrigeration technique which uses electrical compressor to accomplish the same cooling effect. Unlike vapor compression refrigerator, absorption refrigerator could be driven by various energy sources and methods, e.g. (1) It can be powered by conventional electric energy, by means of a heating coil, to heat the solution mixture in the generator; (2) It can be driven by low heat source energy, such as waste heat, to heat the solution mixture in the generator; and (3) It can be driven by external heating of fossil fuel, by means of a gas burner, such as LPG.

The absorption cycle can be powered by waste heat. The ability to use unwanted heat causes such system to gain popular in the commercial cooling for energy recycle applications. Absolute low noise also is one of the added advantages of the absorption refrigerator, as pointed out by Horuz and Callander [1]. Moreover, it had been reported to cause zero or minimum ozone depletion by Misra et al. [2], etc., because it does not use any CFC or HFCs refrigerant as the working fluids.

Afif et al. [3] had conducted a study on the first and second law analysis of a power and refrigeration thermodynamic cycle using a solar heat source. In 2004, Horuz and Callander [1] had conducted an experimental investigation of a 10 kW vapor-absorption refrigeration system powered by natural gas to produce chilled water. In both papers, only the COP of the system under different energy sources was found. No detail techno-economical study is given in the papers.

In 2005, Misra et al. [2] have conducted the thermoeconomic evaluation and optimization of aqua-ammonia vapor-absorption refrigeration system. The objective was to use the thermoeconomic concept to minimize its overall production cost. In 2001, Ajib [4] from Germany has conducted the research on the profitability

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