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Feasibility of a compact heat recovery ventilator module with an integrated air-cooled solar absorption air-conditioner

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ABSTRACT

A solar absorption air-conditioner is simulated with an air-to-air heat exchanger to evaluate the feasibility of a compact solar air-conditioning ventilator module. The air-to-air heat exchanger considered in this study is a membrane type total exchanger and the absorption air-conditioner is a single-effect LiBr-water machine with air-coil heat exchangers. All components are modeled in effectiveness-NTU methods including a dehumidifying DX evaporator coil and a cross-flow absorber allowing the whole system to be described by a set of simultaneous algebraic equations, which are then solved easily by a matrix solver. It is predicted that the baseline air-conditioner would produce cooling power in 1.4–5 kW from hot water in 50–100 °C with a COP_{thrm} over 0.7 without the risk of crystallization and that the heat transfer coefficients of the air-coils and the pressure losses would greatly influence the performance. Total cooling power of the baseline system at 80 °C hot water temperature condition is found 19.2 kW, of which 15.7 kW is attributable to AHX and 3.5 kW to the absorption air-conditioner. Corresponding total COP_{elec} is 76, to which the contributions of AHX and the absorption air-conditioner are 62 and 14, respectively. Air flow rates are found to greatly influence the overall performance and should be carefully chosen. It is concluded that the proposed idea is technically feasible and worth further development as an alternative solution.

1. Introduction

Ventilation is not only necessary but also often legally required to guarantee an acceptable level of indoor air quality for human health and comfort in the confined space where occupants are directly exposed to the airborne pollutants from various internal sources. In Korea, the Ministry of Land, Transport and Maritime Affairs amended the Regulation on Equipment Standards for Buildings [1] in 2009 so that a new or renovated apartment building and multiuse facilities be equipped with ventilation systems to meet certain minimum ventilation requirement specified for the type and size of the facility. With the ever-rising energy prices, energy-saving ventilation became a hot issue in Korea and the market for HRV (Heat Recovery Ventilator) is growing [2].

This study is intended to evaluate the idea of integrating HRV with a solar-powered air-conditioner. The idea itself is not new as various solar-driven cooling machines (e.g. sorption chillers, desiccant-assisted evaporative coolers) have been used with HRVs in many air-conditioning systems [3–5]. The conventional technology needs, however, several closed and/or open hydronic loops (often with a wet cooling tower) and hence large installation space as well as high costs. On the other hand, the absorption air-conditioner proposed in this study needs only one hydronic loop for hot water (37 → 38 in Fig. 1) so that it could be easily integrated with HRV to make a compact module, which can be simply dropped into the existing facilities. Besides, the air-conditioner is a completely closed unit and would require much less operating cost. These features can be very attractive especially for the building owners who have interest but hesitate for the drawbacks with the conventional solar cooling technologies.

The absorption air-conditioner in Fig. 1 has air-coil heat exchangers for the condenser, absorber and evaporator. The condenser and absorber reject waste heat to the exhaust air stream while the evaporator removes heat from the supply air. Due to the risk of contaminating the process air, the working fluids in the air-conditioner should be non-toxic and non-flammable. This requirement excludes use of ammonia, which is probably the most popular refrigerant used for air-cooled absorption machines [6–10]. Water may be ideal for this application but it has been limited mostly to water-cooled chillers due to the large volume of steam at low pressure. Nevertheless there has been continuous effort to develop air-cooled chillers [9,11–23]. The problems in developing air-cooled

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