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Editorial

Special Issue: "Emerging Technologies in Heating, Ventilation, Air Conditioning and Refrigeration (HVAC&R) Systems"

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1. Introduction

Heating, ventilation, air conditioning and refrigeration (HVAC&R) systems provide physical environment comfort for the occupants at a possible expense of large amount of energy consumption. Researchers have made great efforts to develop novel technologies for both alleviating the impact of operating HVAC systems on the environment and saving energy. In addition, the current global pandemic has had enormous impacts on social activities and the economy, leading to new challenges in the development of HVAC&R systems and technologies with improved energy efficiency, especially for miscellaneous applications.

This Special Issue on "Emerging Technologies in Heating, Ventilation, Air Conditioning and Refrigeration (HVAC&R) Systems" collected and reported novel technologies and advances in HVAC&R. Based on these collected reports, important findings are summarized below.

2. Characteristics of the Modern Refrigerants

Hung et al. [1] investigated the integrated part-load performance, integrated part load value (IPLV) and internal flow field of the magnetic centrifugal refrigerant compressors with different refrigerants, such as R-134a, R-513A and R-1234yf, as working fluids using the computational fluid dynamics technique. Their results showed that the maglev centrifugal refrigerant compressor efficiency appreciably dropped as the original refrigerant R-134a was replaced by R-513A and R-1234yf. Compared to R-134a, the full load efficiencies dropped 13.21% and 9.97% with R-1234yf and R-513A, respectively, as working fluids. The values for partial-load efficiency, however, were similar to R-134a.

Kumar et al. [2] investigated the nucleate pool boiling heat transfer of low-global-warming-potential (GWP) refrigerant R-1234ze(E) on enhanced GEWA-B5H tube with the addition of a highly viscous oil, POEA-220, at saturation temperatures of 10 °C, 0 °C and −6 °C. It was found that compared to the pure R-1234ze(E) in the moderate heat flux range, an enhancement in the heat transfer coefficient at saturation temperatures of 0 °C and −6 °C can be achieved with the addition of 10% mass fraction of the POEA-220 oil into R-1234ze(E). Moreover, for the R-1234ze(E)/POEA-68 mixtures, a 5% mass fraction of oil showed no enhancement in the heat transfer coefficient compared to pure refrigerant at the same saturation temperature. Moreover, at low saturation temperatures (0 °C and −6 °C), the enhancement in the heat transfer coefficient decreased with the increase in mass fraction of low-viscosity oil POEA-68, whereas high-viscosity oil POEA-220 showed the highest enhancement in the heat transfer coefficient for a 5% mass fraction of oil at a saturation temperature of −6 °C compared to the pure R-1234ze(E). The results indicate that for nucleate boiling, the effect of oil viscosity on heat transfer performance is negligible if the refrigerant has high thermal conductivity and low surface tension.

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3. Novel Design of the HVAC&R Related Products

Liu et al. [3] conducted CFD simulation on the airflow in a 4.3 m long, 3.0 m wide and 2.0 m high room with an air purification equipment installed to explore whether it has a blocking effect. Prior to the simulation, the P-Q curves of the fan in the air purifier at various rotational speeds were measured in a wind tunnel. Results indicated that the air purification equipment can be set to form a wind wall for effectively blocking the airflow from a person sitting opposite. High air flow beyond the optimized value, however, results in turbulence that deviates the airflow from the intended direction. This in turn causes cross airflow between the adjacent people and increases the chance of infection.

Yang et al. [4] examined the performance of three heat pump dryers using R-134a as the refrigerant for the heat pump system and moist sodium polyacrylate (Orbeez) as the drying material. It was found that the COP of the heat pump system was maximized at lower test loads when an external desiccant wheel was incorporated into the heat pump system. Because of the better penetration of drying air at a lower test load, the moisture extraction rate at a lower test load was higher than that at a higher test load, although the maximum test load showed the maximum relative humidity at the dryer outlet. The desiccant wheel showed good performance in terms of moisture extraction rate (MER) and COP_{HP} but poor performance in terms of the specific moisture extraction rate due to the high power consumption of the desiccant dehumidifier. The MERs for all designs increased to a maximum value and then declined.

Yang et al. [5] experimentally examined the applicability of ice storage systems with R-404A as the working fluid in small commercial refrigerated showcases. In the ice storage system, the condenser is changed from air cooling (refrigeration mode) to immersion type that is placed in an ice storage tank. The corresponding condensing temperature and pressure are significantly reduced, leading to an increase in efficiency and effective reduction in the peak power consumption. With the reduction in the condensing temperature and pressure, the coefficient of performance (COP) increased from 3.6 (refrigeration mode) to 6.35 (melting mode). In addition, the power load was shifted approximately 35% during peak hours, and the energy cost was lowered by USD 17.13 per month.

4. Heat Pipe Heat Exchangers

Gupta et al. [6] developed a gas-to-liquid heat pipe heat exchanger (HPHE) on the basis of numerical and experimental analyses. Stainless-steel heat pipes with copper mesh as the wick structure were installed inside a heat exchanger to recover waste heat from the hot exhaust gas to the water flow. It was found that the temperature and velocity of the inlet air are directly proportional to the heat transfer rate from the air to the cooling water. However, the effectiveness was greater as the temperature and velocity of the inlet air were reduced. The numerical study showed a maximum increase of 12% on heat transfer can be achieved. The maximum increases in the output temperatures of hot and cold fluids reached 7 K and 3 K, respectively.

Yang et al. [7] proposed a novel design of an unfinned thermosyphon HPHX with a continuous closed tube loop, which requires only a single charge for industrial waste heat recovery. The HPHX consists of 9×17 straight copper tubes in a staggered arrangement connected by 144 U bends. The thermal performance of this novel thermosyphon HPHX charged with water at a filling ratio of 40% was measured. The evaporator section of the HPHX is immersed in hot silicone oil, while its condenser section is cooled by the air flow. The heat transfer rate of 6.65 kW can be achieved with the evaporation section of the HPHX being immersed in a 150 °C oil bath at a cooling air flow rate of 1600 CMH. The maximum effective thermal conductivity of the HPHX reached 12,798 W/m·K. Based on the prediction of an ε-NTU theoretical model for single-tube thermosyphons with boiling and film condensation, this indicates that the total resistance R_{tot} of the HPHX decreases as the heat transfer rate and the airflow rate increase.

Conflicts of Interest: The authors declare no conflict of interest.

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