

Performance analysis of a novel thermoelectric assisted direct evaporative cooling system

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1. Introduction

With the advantages of energy conservation and environmental protection, sustainability, low installation and maintenance costs, evaporative cooling is considered as one of the most suitable alternative, or as a pre-cooler of common refrigerant-based air conditioning systems in building air conditioning and data center cooling. Despite the great efforts of researchers, standalone evaporative cooling systems still face certain difficulties like lower cooling air temperature reduction, larger size, and higher dependency on climate conditions. Thus, different combinations of cooling systems have been explored by combining the IEC system with the DEC system or any of these with other kinds of cooling systems to further enhance the systems' cooling performance.

Inspired by the previous research results, a novel thermoelectric assisted direct evaporative cooling (DEC) system is proposed. This system takes full advantages of evaporative cooling like using nature fluids (water and air), high COP, simple structure and low cost, and could also overcome the shortcoming of evaporative cooling i.e. high dependence on climate conditions with the assistance of the TEC modules.

2. System Description

The schematic diagram of the TDEC cooler is shown in Figure 1(a). The thermoelectric cooling (TEC) modules are placed between air and water channels. The cold side is attached to the air channel and the hot side to the water channel. The circulated spray water is considered to be uniformly distributed on the plate surface of the air channel by the water pump and the nozzles. While the spray water flows down along the surface of the plate as water film, it absorbs the cooling capacity released by the cold side of the TEC modules and exchanges heat and mass with the air. The cooling water is used to absorb heat released by the hot side of the TEC modules. Figure 1(b) shows schematic diagrams of the TDEC system. The cooled air is sent into the room to provide cooling capacity. The cooling water that absorbs the heat released by the TEC modules is cooled by the cooling tower.

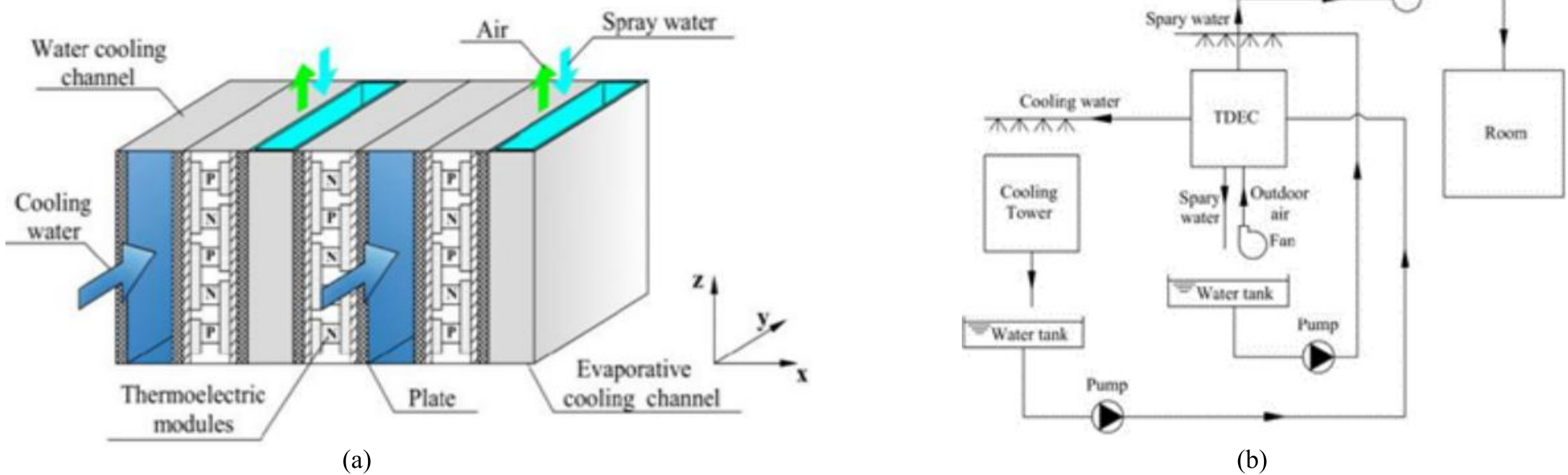


Figure 1: (a) Schematic diagram of the TDEC cooler; (b) Schematic diagram of the TDEC system

3. Results and discussion

Table 1. Main operating parameters

Operating parameters	Value
Dry-bulb temperature of air	35°C
Relative humidity of the inlet air	40%
Mass flow rate of air	4.5g/s
Mass flow rate of cooling water	0.1kg/s

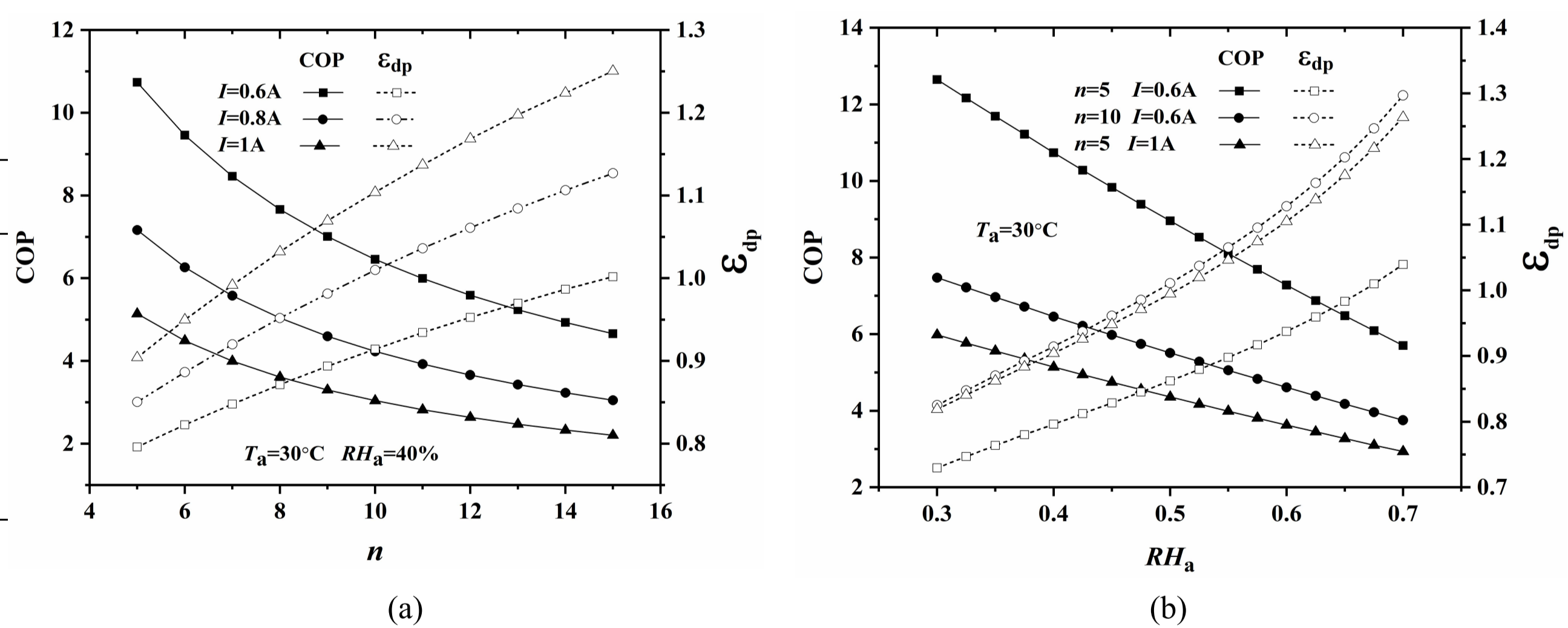


Figure 2 : (a) COP and ϵ_{dp} versus the working electric current I under different TEC module number n
(b) COP and ϵ_{dp} versus the relative humidity RH_a

Table 2. Main geometrical parameters

Geometric parameters	Value
Cooler height	0.5 m
Cooler length	0.5 m
Width of air channel	5mm
Width of water channel	5mm

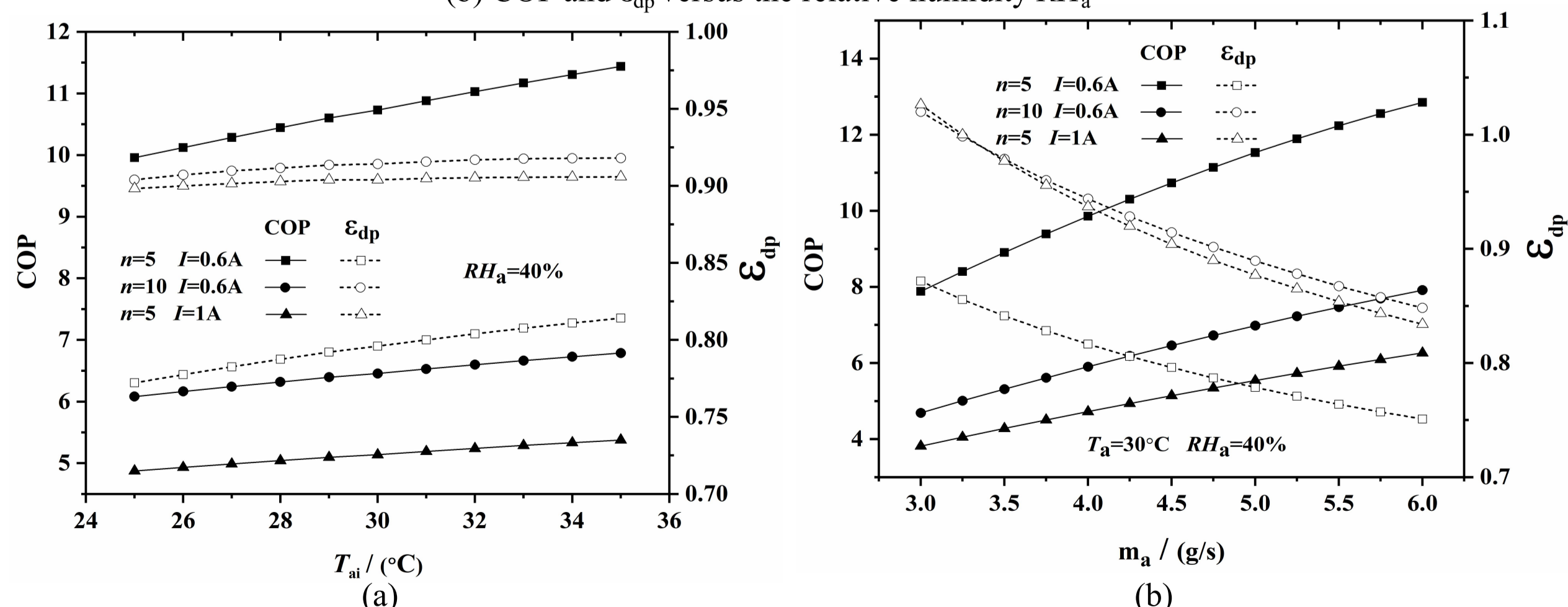


Figure 3 : (a) COP and ϵ_{dp} versus the air inlet temperature T_{ai} ;
(b) COP and ϵ_{dp} versus the air mass flow rate m_a

4. Conclusions

This paper proposes a novel thermoelectric-assisted direct evaporative cooling (TDEC) system. The highlighted results lead to the following conclusions:

(1) By increasing the working electric current I and the number of thermoelectric cooling modules n , the air can be cooled to below the wet bulb temperature or even below the dew point temperature;

(2) The smaller air inlet relative humidity RH_a and larger air inlet temperature T_{ai} would produce larger COP. Larger RH_a and larger T_{ai} would produce larger dew point efficiency ϵ_{dp} ;

(3) With the increase of m_a , COP increases but the ϵ_{dp} decreases.

In general, the developed model for the novel system and obtained results could provide theoretical guidance for designing and optimizing of this kind of thermoelectric assisted DEC systems for air conditioning applications.