CHAPTER 7
CONCLUSIONS AND FUTURE SCOPE

7.1 Conclusions

In this thesis, eight possible configurations (four parallel/counter flow and four cross flow) of the regenerative evaporative cooler are investigated based on energetic, exergetic, economic, and environmental aspects. Further investigation on the regenerative evaporative coolers is done by using various hybrid nanofluids as coolant as well as various surface profiles (flat plate, capsuled, fin attached, corrugated) of the cooling plate for performance improvement. A dual-mode evaporative cooler is developed and experimentally evaluated the energy, exergy, economic and sustainability indices in both operating modes (direct and regenerative). The month-wise performance of the full-fledged dual-mode cooler in both modes is examined for various Indian cities as well as distinct worldwide (international) climatic zones using ASHRAE climatic data. Finally, the data of the previous 20 years is utilized to anticipate the climatic conditions for the future ten years and the performance and usefulness of the dual-mode evaporative cooler are forecasted for various climate zones. The main inferences from the present study can be summarised as follows:

- Within studied possible system configurations, two configurations (A and H) are found best for the regenerative evaporative cooler.
- Application of only hybrid nanofluid as cooling fluid in the regenerative evaporative cooler is not fruitful due to marginal performance improvement; whereas, surface modifications techniques (such as capsule embossment) should be used in the evaporative cooler to enhance the performance of the device.

- For the dual-mode evaporative cooler, REC mode is better in terms of dew-point effectiveness and exergy efficiency; whereas, DEC mode is better in terms of cooling capacity, COP and specific total cost. Hence, DEC mode should be preferred until it provides cool air out of thermal comfort.
- The colder water temperature improves (slightly) the device's cooling performance. The temperature of the water input is particularly important in the regenerative mode. The efficacy of the cooler rises slightly as the water flow rate increases, while the cooler's COP decreases. Hence high flow rate is not recommended.
- The dual-mode evaporative cooler can be automated to operate in DEC or REC mode by sensing outdoor conditions (DEC mode can be switched to REC mode if the wet-bulb temperature of intake condition is greater than 24 ºC and vice-versa).
- About 40% annual cost saving is possible by using the dual-mode cooling device instead of two single-mode (DEC and REC) devices for the composite climate.
- The proposed dual-mode device is more economical in operation in both modes when compared to conventional vapor compression-based cooling devices. This system is simple and cost-effective, which is applicable for composite and hot-dry climate zones with increased utility months.
- The REC mode of the dual-mode cooling device is suited for all six months, while the DEC mode can also be used in dry months (April and May) only in the 2030 scenario. The usability duration of REC will improve in the future.
- The hot and humid climate will remain unsuitable for DEC mode for investigated months. The usability hours of REC mode will decrease in the future. The desiccant-assisted evaporative cooling may be useful for this case.

- ❑ In the futuristic (2030) composite climatic condition, only two dry months will remain suitable for DEC and five months for REC modes of the dual-mode cooler. The usability duration of both modes will remain the same in the future.

7.2 Future scope

Both numerical and experimental works are carried out and the presented work can be extended to contribute significantly by following points of consideration.

- The dual-mode evaporative cooler can be tested as a standalone cooling system for daylong operation in different climatic zones and real-time data can be collected.
- A combined system of desiccant dehumidification and dual-mode evaporative cooling should be investigated to enhance the applicability.
- The dual-mode evaporative cooler can be fabricated with the different surface modifications and experimented with for performance enhancement.
- The computational fluid dynamics (CFD) analysis of the regenerative evaporative cooler should be done with different surface modifications.
- An intelligent evaporative cooler can be developed, which can automatically switch from one mode to another just by sensing outdoor humidity.

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