New generation of materials and processes for environmentally compliant refrigeration

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Abstract

There is a steady increase in cooling demand worldwide. The majority of these cooling demands are satisfied by conventional vapor compression refrigeration (VCR) units. Choosing a proper refrigerant for a VCR unit is challenging when technological, environmental, and safety problems are all taken into account. As VCR units run on electricity and the majority of the global electricity demands are still catered by fossil fuel-based power plants, conventional VCR units indirectly contribute to global carbon emissions. In this chapter, the operating principles of conventional and enhanced VCR units are discussed first, followed by an identification of possible refrigerants for their functioning in the current energy landscape. The chapter also investigates thermally driven refrigeration units and their operation, focusing on suitable refrigerants and refrigerant-absorbent pairs for reducing local electricity consumption. Solid state refrigeration units (such as thermo-electric coolers, magnetic refrigeration) are gaining interest due to the negative environmental impact of conventional refrigerants. Therefore, the chapter focuses on the operational and material selection aspects of a few solid state refrigeration units. In a word, the present chapter summarizes materials and processes needed for environmentally compliant cooling/refrigeration and it would be helpful for researchers working on sustainable cooling technology.

Key points

- Conventional and advanced refrigeration technologies are identified
- The working principle of these refrigeration technologies demonstrated
- Environmentally compliant materials/refrigerant needed for efficient cooling are summarized

1 Introduction

Demand for cooling is steadily increasing with improved standard of living (OECD/IEA, 2018). The majority of the global cooling needs are satisfied by vapor compression refrigeration (VCR) units. The performance of a vapor compression refrigeration unit greatly depends on the selection of a suitable refrigerant. As most of the conventional refrigerants either are flammable or produces adverse effects on nature, selection of suitable refrigerant is quite challenging (Mondal and De, 2020a).

A VCR unit consumes a substantial amount of electricity to produce a unit refrigeration effect. As the majority of the global electricity demand is satisfied by fossil fuel based power plants, VCR units are indirectly responsible for greenhouse gas emissions. However, power consumption per unit refrigeration effect (or Mechanical COP) of a VCRC unit can be significantly reduced by using an ejector as the expander. Local electricity consumption can be significantly reduced by employing some heat-driven refrigeration units (absorption chillers, heat-driven ejector chillers, etc.) to satisfy the local cooling needs.

Solid state refrigeration units (such as thermo-electric coolers, magnetic refrigeration) are recently gaining interest due to the negative environmental impact of conventional refrigerants. Non-availability of high performing materials is the main constraint in