



GUJARAT TECHNOLOGICAL UNIVERSITY

(Established by Government of Gujarat under Gujarat Act No. : 20 of 2007)

ગુજરાત ટેકનોલોજીકલ યુનિવર્સિટી

(ગુજરાત સરકારના ગુજરાત અધિનિયમ ક્રમાંક : ૨૦/૨૦૦૭ દ્વારા સ્થાપિત)

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Abstract of the Thesis



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Faculty: Engineering

Discipline/Branch: Mechanical Engineering

Title of the Thesis: Investigation and Performance Analysis of Solar-Powered Adsorption Refrigeration System

Abstract

The increasing demand for refrigeration and air-conditioning, together with concerns regarding conventional energy consumption and environmental impact, has increased interest in alternative and sustainable cooling technologies. Solar-powered adsorption refrigeration systems offer a potential alternative because they can utilize renewable solar energy and operate without conventional mechanical compression. However, their practical application is influenced by relatively low coefficient of performance, intermittent operation, and variations in solar energy availability. Therefore, experimental investigation of such systems under actual outdoor operating conditions is important for understanding their performance and limitations.

The present study investigates the design, development, and performance evaluation of a solar-powered adsorption refrigeration system employing activated carbon as the adsorbent and methanol as the refrigerant. The developed system consists of a flat-plate solar collector integrated with an adsorber, an air-cooled condenser, an evaporator, and associated connecting and control arrangements. The system operates on an intermittent adsorption-desorption cycle, in which solar energy is utilized to heat the adsorbent bed and desorb the refrigerant, followed by condensation, evaporation, and adsorption to produce the required cooling effect.



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An experimental investigation was carried out under actual outdoor conditions during the March–May 2025 experimental campaign at Vadodara, Gujarat, India. Experimental observations were recorded manually at one-hour intervals during each 24-hour adsorption–desorption cycle. The measured parameters included solar radiation, ambient temperature, adsorber temperature, condenser temperature, evaporator temperature, load water temperature, and relevant system pressures. The experimental data were processed to evaluate the refrigeration effect, cooling capacity, system coefficient of performance (COP), solar COP, and specific cooling power (SCP). Detailed day-wise observations and uncertainty analysis are provided separately in the annexures.

The experimental results demonstrate that the performance of the developed system was influenced by variations in solar radiation and operating conditions during the March–May 2025 experimental period. The results indicate an improvement in the refrigeration effect and calculated performance parameters under favourable solar operating conditions. Among the representative experimental days analyzed, the best performance was observed on 23 May 2025, corresponding to an average solar radiation of 606.02 W/m², with a system COP of 0.1727, solar COP of 0.0691, and SCP of 10.46 W/kg.

Energy and exergy analyses were also performed using representative experimental data from March, April, and May 2025 to evaluate the thermodynamic performance of the developed system. The analysis provided an assessment of solar energy utilization, refrigeration performance, and selected exergy characteristics of the system. The results indicate that the collector–adsorber assembly and associated heat transfer processes have an important influence on the overall thermodynamic performance and offer potential areas for further improvement.

The study demonstrates the technical feasibility of a solar-powered activated carbon–methanol adsorption refrigeration system for water cooling under the outdoor conditions investigated during March–May 2025. The findings provide experimental information on the performance of a locally developed adsorption refrigeration system and may contribute to further improvements in solar collector–adsorber design, heat and mass transfer characteristics, operating strategies, and overall system performance.



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This PhD thesis will help in development of sustainable and energy-efficient solar-powered cooling systems and provide experimental insights for improving the design, performance, and thermodynamic efficiency of adsorption refrigeration systems.

List of Publication(s):

1. Swati Prajapati, Dinesh K. Patel, Hitesh Bhargav, Choon Kit Chan, Subhav Singh and Deekshant Varshney (2026), “Performance enhancement of activated carbon-methanol solar adsorption system using coaxial collector and dual-valve stability,” *International Journal of Thermofluids*, Vol. 33, Article 101608, Elsevier, ISSN: 2666-2027. (Scopus Indexed, Open Access)
DOI: <https://doi.org/10.1016/j.ijft.2026.101608>
2. Swati Prajapati, Dinesh Patel, Simit Prajapati and Bindi Thakkar (2026), “Design of Evaporator and Condenser for Solar Adsorption Refrigeration System,” *Journal of Refrigeration, Air Conditioning, Heating and Ventilation*, Vol. 13, Issue 2, May–August 2026, pp. 1–10, ISSN: 2394-1952. (Peer-Reviewed Journal)
DOI: <https://doi.org/10.37591/JORACHV.v13i02.243898>
3. Swati Prajapati, Dinesh Patel, Bindi Thakkar and Simit Prajapati (2026), “The design, development of a solar powered adsorption cooling system for Indian conditions,” *Discover Mechanical Engineering*, Vol. 5, Article 159, Springer Nature, ISSN: 2731-6726 (Online). (Scopus Indexed, Open Access)
DOI: <https://doi.org/10.1007/s44245-026-00340-6>