



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)

Accredited with A+ Grade by NAAC

Abstract of the Thesis



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Faculty: Mechanical Engineering

Discipline/Branch: Mechanical Engineering

Title of the Thesis: Investigation of High Wattage LEDs Using Hybrid Nano Fluid Filled Heat Pipe

Abstract

Light-Emitting Diodes (LEDs) have emerged as one of the most efficient and cost-effective lighting solutions in current electro-optical applications. Thermally controlled LEDs offer a longer lifespan and a significantly lower danger of overheating failure. The most economical, compact, and effective cooling system must be developed to improve heat dissipation. The performance of LEDs for high-wattage applications has been the subject of extensive investigation. The use of LEDs in high-wattage practical applications is the main focus of the current work. The hybridization of nano-additives to get synergic effect of individual one is needed to be investigated. Researchers have examined high-wattage LEDs rated at 100 W, 200 W, and 400 W for use on streets, in stadiums, and on high-mast towers, respectively. A two-layer cylindrical copper heat pipe with a screen-mesh wick structure has been designed and fabricated to cool LEDs. Dispersed Cu and SiO₂ nanoparticles in DI water have been used as the working medium for a heat pipe.



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Working medium categories, filling proportions, and LED wattage were all considered as input variables during the experiment. Variables generated include the condenser-evaporator temperature differential, thermal resistance, energy consumption, Effective Thermal Conductivity (ETC), and the overall Heat Transfer Coefficient (HTC). A specific experimental setup with the necessary measurement and control equipment has been developed for performance analysis. In comparison to Deionized (DI) water, Cu/DI water, SiO₂/DI water, Cu: SiO₂ (25:75)/DI water, and Cu: SiO₂ (50:50)/DI water for 100 W LED had shown an exceptional result, the Cu: SiO₂ (75:25)/DI water filled heat pipe taking into consideration the LEDs' 60% filling ratio executed 25.5%, 12.2%, 15.3%, 14.5%, and 3.7% lower temperature difference respectively.

This PhD Thesis will help in

The thesis contributes both academically and practically by advancing the understanding of high-powered LED cooling through copper heat pipes integrated with hybrid nanofluids, offering experimental validation of enhanced thermal performance. The work not only strengthens the scientific foundation for sustainable lighting technologies but also demonstrates techno-economic feasibility for large-scale applications such as industrial, street, and stadium illumination. By improving energy efficiency, extending LED lifespan, and reducing environmental impact, the research provides a valuable bridge between laboratory innovation and real-world implementation, while opening pathways for future studies in adaptive and hybrid cooling strategies.

List of Publication(s):

List of Research Paper(s):

1. A Khudaiwala, R. L. Patel, and R. Bumataria, "Recent developments in thermal management of light-emitting diodes (LEDs): A review," Journal of Thermal Engineering,



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vol. 10, no. 2, pp. 517–540, Mar. 2024, doi:10.18186/thermal.1457052.

2. A Khudaiwala, R. L. Patel, “Performance investigation of high-powered light emitting diodes using copper and silicon-oxide based nanofluid filled heat pipe,” Journal of Thermal Engineering, vol. 12, no. 1, pp. 16–28, 2025, doi: 10.14744/thermal.0001055.
3. A Khudaiwala and R. Patel, “Techno-Economic Analysis of High-Powered Light Emitting Diodes Using Heat Pipe Filled with Copper and Silicon-Dioxide-Based Nanofluid,” vol. 13, no. 3, pp. 24659–24675, 2026.

List of Patent(s):

1. A Khudaiwala, R. L. Patel, and R. Bumataria, (2025). A nanofluid composition and a heat pipe system for passive thermal management of High-wattage LEDs. Indian Patent Application 202521056038 A, published July 2025.

<https://iprsearch.ipindia.gov.in/PublicSearch/PublicationSearch/PatentDetails>