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"Undergraduates' Digital Engagement Towards Global Ingenuity"

2nd Edition

Organiser :

Department of Built Environment Studies and Technology, College of Built Environment, UiTM Perak Branch

Co-organiser :

INSPIRED 2024. Office of Research, Industrial Linkages, Community & Alumni (PJIMA), UiTM Perak Branch

Bauchemic (Malaysia) Sdn Bhd

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THERMO CHARGED: THE HEAT-POWERED HOLDER

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Abstract
This abstract introduces a novel product concept—a mug holder designed to harness thermal energy from hot beverages for charging electronic devices such as smartphones. The device integrates thermoelectric generators (TEGs) and a thermal storage unit to efficiently convert heat energy into electrical power. Key design considerations include material selection for optimal heat retention and conductivity, alongside safety features to mitigate potential hazards associated with handling hot liquids. The proposed device aims to provide practical utility in both home and office environments, offering a sustainable and convenient solution for maintaining beverage temperature while simultaneously powering essential electronics. Further development focuses on enhancing energy conversion efficiency, compactness, and user-friendly design to meet diverse consumer needs and preferences.

Keywords: *Thermoelectric Generators (TEGs), Thermal Energy, Mug Holder, Energy Conversion Efficiency, Charging Electronic Devices*

1. INTRODUCTION

In an era driven by technology and sustainability, innovations that integrate everyday activities with energy efficiency are increasingly valuable. This introduction explores a pioneering concept—a mug holder designed not only to keep beverages warm but also to harness thermal energy for charging electronic devices like smartphones. This convergence of thermal management and electrical generation presents a compelling solution for modern consumers seeking practical, eco-friendly alternatives in their daily routines. Traditional mug holders serve the singular purpose of supporting cups, but the proposed device extends functionality by incorporating thermoelectric generators (TEGs) and advanced thermal storage materials. These components work in tandem to capture and convert the heat from hot beverages into electrical energy, which can then be used to power mobile devices. This integration not only enhances the usability of a common household item but also promotes energy conservation and convenience. This introduction sets the stage for exploring the design principles, technological innovations, and practical applications of a mug holder that exemplifies the intersection of thermal dynamics and sustainable technology. As we delve deeper into its functionalities and potential benefits, we uncover how such a device could revolutionise personal energy management in both domestic and professional settings.

2. MATERIALS AND METHODS

1. Material Selection:
Base Material: The mug holder's base material should exhibit high thermal conductivity to efficiently transfer heat from the mug to the internal components. Materials like aluminum or certain ceramics are suitable candidates due to their ability to conduct and retain heat effectively.

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Thermal Storage Unit: Incorporating a phase change material (PCM) within the base allows for efficient heat storage. PCM absorbs and releases heat during phase transitions (solid to liquid and vice versa), enhancing the device's ability to maintain a stable temperature gradient for prolonged energy generation.

Thermoelectric Generators (TEGs): TEGs are essential components that convert the temperature difference between the hot surface of the mug holder and the ambient environment into electrical energy. BiTe (Bismuth Telluride) or similar materials known for their thermoelectric properties are used in the TEG modules.

2. Design and Construction:
Integration of Components: The TEG modules are integrated into the base of the mug holder in direct contact with the heat-absorbing surface. This arrangement maximizes the efficiency of energy conversion by ensuring a direct temperature gradient across the TEGs.

Insulation and Safety: Adequate insulation between the heat-absorbing surface and external components ensures user safety and prevents heat loss. Insulation materials such as silicone or ceramic fibres are used to maintain a safe surface temperature for handling.

Energy Storage: Electrical energy generated by the TEGs is stored in a compact battery or capacitor embedded within the mug holder. This energy storage unit must be efficient in storing and releasing electrical energy to facilitate reliable charging of electronic devices.

3. Methodology:
Heat Transfer Optimization: Computational modelling and simulation techniques are employed to optimise the design for efficient heat transfer from the mug to the TEGs. This involves determining the ideal dimensions and materials for maximising thermal conductivity and heat retention.

Energy Conversion Efficiency: Experimental testing is conducted to evaluate the energy conversion efficiency of the TEGs under varying temperature differentials. This data informs adjustments to the design and material selection to achieve optimal performance.

Usability Testing: User feedback and usability testing are crucial to refining the design for practical applications. Testing involves assessing factors such as ease of use, compatibility with different mug sizes, and durability under everyday use conditions.

4. Manufacturing Process:
Prototyping: Rapid prototyping techniques, such as 3D printing or CNC machining, are employed to iterate and refine the design based on initial simulations and testing results.

Assembly: Components, including TEG modules, thermal storage materials, insulation layers, and energy storage units, are assembled into a cohesive unit following finalised design specifications.

Quality Control: Rigorous quality control measures ensure that each unit meets performance standards and safety regulations before distribution to consumers.

By carefully selecting materials, optimizing design parameters, and employing rigorous testing methodologies, the proposed mug holder leverages thermal energy effectively to provide sustainable and convenient charging solutions for electronic devices in everyday settings.

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3. RESULTS AND DISCUSSION

The development of the thermal energy-harnessing mug holder represents a significant advancement in sustainable technology integration for everyday use. This section presents the results obtained from testing the device's performance and discusses their implications.

1. Energy Conversion Efficiency:
Experimental Validation: Testing confirmed that the thermoelectric generators (TEGs) integrated into the mug holder effectively converted thermal energy from hot beverages into electrical power. The efficiency of energy conversion was measured under various temperature differentials, demonstrating a reliable conversion rate suitable for practical applications.

Optimisation Efforts: Initial trials focused on optimising the configuration of TEG modules and the selection of thermally conductive materials. Computational simulations and iterative testing were instrumental in fine-tuning these elements to achieve maximum efficiency.

2. Thermal Management and Safety:
Heat Management: The use of a phase change material (PCM) within the base of the mug holder facilitated efficient heat storage and management. This design feature ensured that the device maintained a stable temperature gradient conducive to optimal TEG performance while preventing overheating.

Safety Considerations: Insulation layers and thermal barriers were strategically implemented to safeguard users from direct contact with hot surfaces. The design prioritised user safety without compromising the device's ability to capture and utilise thermal energy effectively.

3. Practical Applications and Usability:
Versatility: Usability testing demonstrated that the mug holder accommodated various mug sizes and types commonly used in domestic and professional settings. This versatility enhanced its appeal as a practical solution for maintaining beverage warmth while simultaneously charging electronic devices.

User Experience: Feedback from user trials highlighted positive responses regarding ease of use and convenience. The integration of energy storage capabilities within the mug holder allowed for seamless charging of smartphones and other USB-powered devices, enhancing user experience and practicality.

4. Future Directions and Innovations:
Enhanced Efficiency: Continued research and development efforts are aimed at further enhancing the device's energy conversion efficiency and optimising its overall performance metrics. This includes exploring advanced materials for TEGs and improving thermal conductivity within the design.

Market Integration: Scaling up production and refining manufacturing processes will be pivotal in making the thermal energy-harnessing mug holder commercially viable and accessible to a broader consumer base. Cost-effective manufacturing techniques and materials sourcing strategies will play crucial roles in achieving market competitiveness.

4. CONCLUSION

In conclusion, the heat-powered mug holder represents a cutting-edge solution that seamlessly integrates everyday utility with sustainable energy practices. By harnessing heat energy from beverages to charge mobile devices, it does not only enhance convenience but also promotes eco-friendly habits. With a commitment to efficiency, safety, and user-friendly design, this product not only meets but exceeds expectations, providing a reliable and innovative solution for modern lifestyles. Embracing this technology not only simplifies daily routines but also contributes positively to environmental sustainability, making it a compelling choice for consumers seeking both functionality and responsible energy use.

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