RESEARCH REPORT

NPD4CE

Abstract

This research report focuses on the analysis and improvement of a traditional kettle design through the lens of sustainability and product design. By utilizing reverse engineering, expert interviews, and desk research, the report identifies key design issues and proposes recommendations to enhance the sustainability, repairability, and user experience of the kettle.

Tony Pulikkottil Lorance

Tonylorance@gmail.com

Contents

1.0 Introduction

The NPD4CE (New Product Development for Upcycling and Circular Economy) project is a research and innovation initiative aimed at exploring new product design ideas that contribute to the circular economy. The project is focused on everyday use electronic products with mixed materials and multiple components that are challenging to disassemble, repair, upgrade, remanufacture, or recycle.

The project is funded by DMU HEIF (Higher Education Innovation Funding) and will run from November 2022 to July 2023. The team comprises three student designers working under supervision, and the project is focused on generating patentable ideas, concepts, and designs that could lead to a spin-out company or attract companies for future consultation and collaboration projects. Overall, the project aims to contribute to the advancement of sustainable and circular product design and inspire future innovations in the field.

1.1Background and context of the project

The world is currently facing a massive environmental crisis, and the manufacturing industry has been identified as one of the main contributors to this crisis. Most products that are currently in the market have been designed and manufactured without much consideration for their end-of-life options, particularly when it comes to the circular economy. This is where the NPD4CE (New Product Development for Upcycling and Circular Economy) project comes in. The project aims to explore new ways of designing and manufacturing products with a focus on upcycling and circular economy. As a student designer, I have chosen to focus on kitchen equipment and specifically on the kettle. Kettles are commonly used in households and are often made with mixed materials, making them challenging to disassemble, repair, upgrade, remanufacture, or recycle.

1.2 Objectives and scope of the research report

The primary objective of this research report is to provide a comprehensive analysis of the kettle as a product, with a specific focus on its end-of-life options and circular economy. The report will be based on desk research, reverse engineering, and product analysis, as well as expert interviews, to identify best practices, innovation gaps, and expert opinions on the direction of innovation in terms of material use, structural change, new technology adoption, and other related areas. The report will also explore some of the most successful projects around upcycling and circular economy and provide insights into how these projects can inform the design and manufacturing of future products, specifically kettles. The scope of the research report will be to suggest radically new products for upcycling and circular economy, with the hope of leading to patentable ideas, concepts, and designs that could lead to a spin-out company and/or attract companies for future consultation/collaboration projects.

2.0 Desk research

2.1 Overview of the literature related to upcycling and circular economy.

This section of the report provides a brief overview of the literature related to upcycling and circular economy, highlighting the key concepts, principles, and benefits of these approaches. Upcycling involves the transformation of waste materials or products into new and higher-value products, while circular economy refers to a regenerative economic system that aims to keep resources in use for as long as possible and eliminate waste. The literature review also discusses the challenges and opportunities of upcycling and circular economy, such as the need for innovative design and manufacturing processes, the importance of stakeholder engagement and collaboration, and the potential environmental, social, and economic benefits of these approaches.

As part of the NPD4CE project, reverse engineering and product analysis were conducted to evaluate the existing design of the chosen product, which in this case is the kettle. The goal was to identify areas for improvement and to come up with new product designs that align with the principles of upcycling and circular economy.

2.2 Selected product

Bosch TWK5P475GB 1.7L Tarbush TWK5P471GB 1.7L Traditional Kettle – White

The Bosch TWK5P475GB 1.7L Traditional Kettle in White is a popular household appliance that is widely used for boiling water. It is a cordless kettle with a capacity of 1.7L and a power output of 3000W. The kettle is made of plastic and stainless steel and has a traditional design. It features a concealed heating element, a removable and washable limescale filter, and an automatic shut-off function. The kettle also has a water level indicator and a 360-degree base for easy handling.

The Bosch TWK5P475GB 1.7L Traditional Kettle in white is a modern and convenient addition to any kitchen. With one-hand operation and lid opening at the touch of a button, this kettle is easy to use. The extra-large water scale allows for easy reading and visibility of the required amount of water, making it perfect for brewing tea or coffee. The kettle also features a triple safety feature, including automatic shut-off, overheat and boil-dry protection, and switch-off when lifted off the base. Additionally, the limescale filter in the spout and concealed heating element make for less limescale build-up and easy maintenance.

3.0 Reverse engineering and product analysis

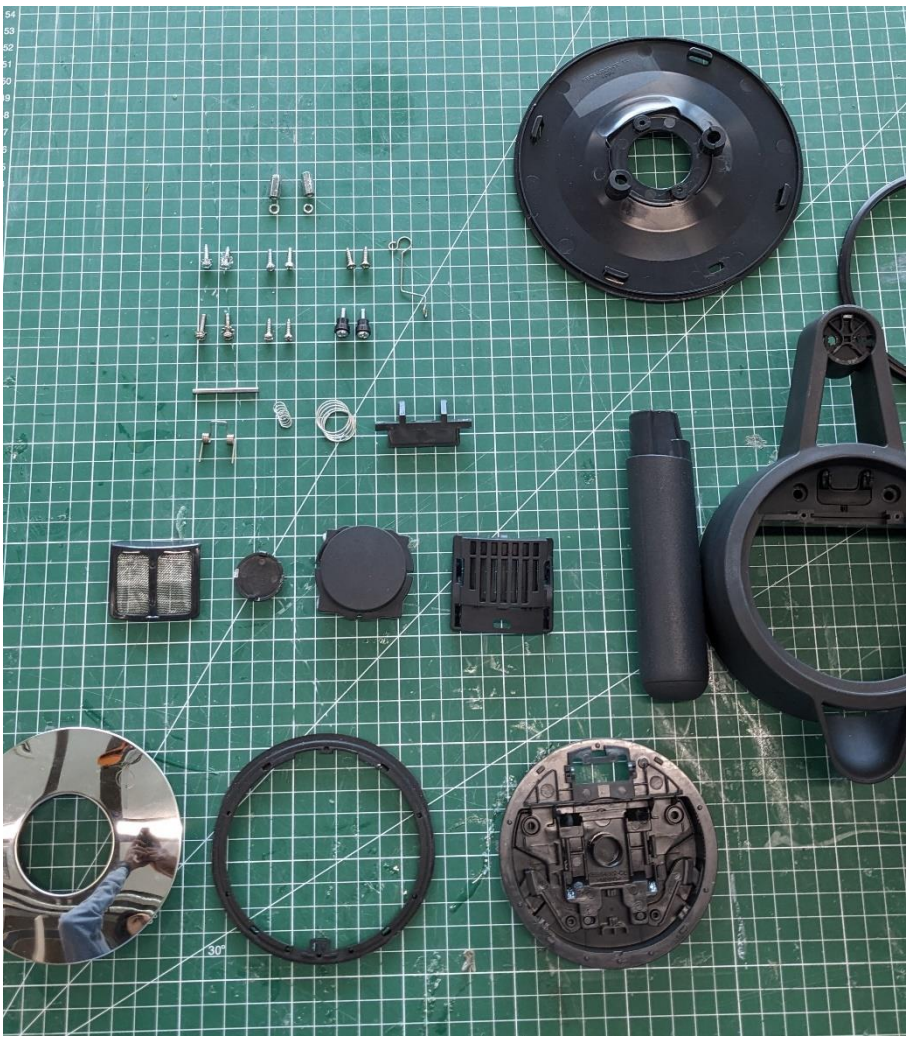
Reverse engineering and product analysis are essential components of the project, allowing for a comprehensive understanding of the existing kettle design. Through a systematic methodology and process, the project undertakes a detailed evaluation of the materials, structure, and functionality of the kettle. This analysis uncovers valuable insights into potential design issues and areas for improvement.

By examining the construction and composition of the kettle, the project identifies specific difficulties faced, such as the challenges associated with press-fit components, limited material durability, and complex mechanisms. Through expert interviews and research, the project gains further insights into the reasons behind certain design choices, such as the use of welded connections for electrical components and the selection of specific materials. The analysis conducted during reverse engineering enables the project team to propose suitable solutions to address the identified problems. By considering factors like accessibility,

repairability, and sustainability, the project aims to enhance the overall design and functionality of the kettle. The findings from this analysis form the basis for the subsequent recommendations and design changes outlined in the report, ultimately contributing to the development of a more sustainable and user-friendly kettle design.

3.1 Methodology and process of reverse engineering and product analysis

The reverse engineering and product analysis were conducted through a systematic process that involved disassembling the kettle, analysing its various components, and evaluating its functionality. The process included a detailed examination of the materials used in the product, its structural design, and its manufacturing process. The information collected during this process was used to identify potential areas for improvement in the design of the kettle.



3.2 Evaluation of the existing kettle design in terms of materials, structure, and functionality

The evaluation of the existing kettle design was done in terms of its materials, structure, and functionality. The materials used in the kettle were identified and analysed to determine their recyclability and potential for upcycling. The structural design was evaluated to identify areas where the kettle could be disassembled for easier recycling or upcycling. The functionality of the kettle was also evaluated to determine if it could be improved for better efficiency and sustainability.

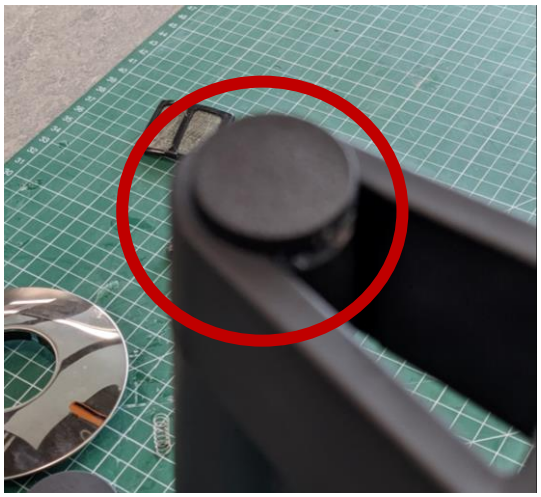
3.3 Identification of potential design issues and areas for improvement

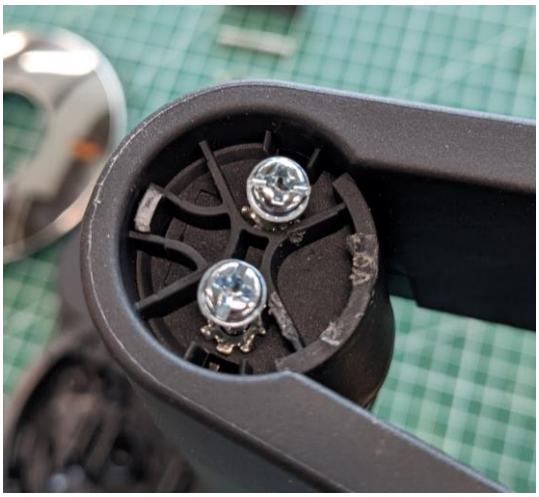
Through the process of reverse engineering and product analysis, potential design issues were identified in the existing kettle design. These issues included difficulty in disassembling the kettle for recycling, non-recyclable or non-up cyclable materials, and inefficiencies in the functionality of the kettle. Based on these issues, areas for improvement were identified, and new product designs were proposed that address these concerns while aligning with the principles of upcycling and circular economy.

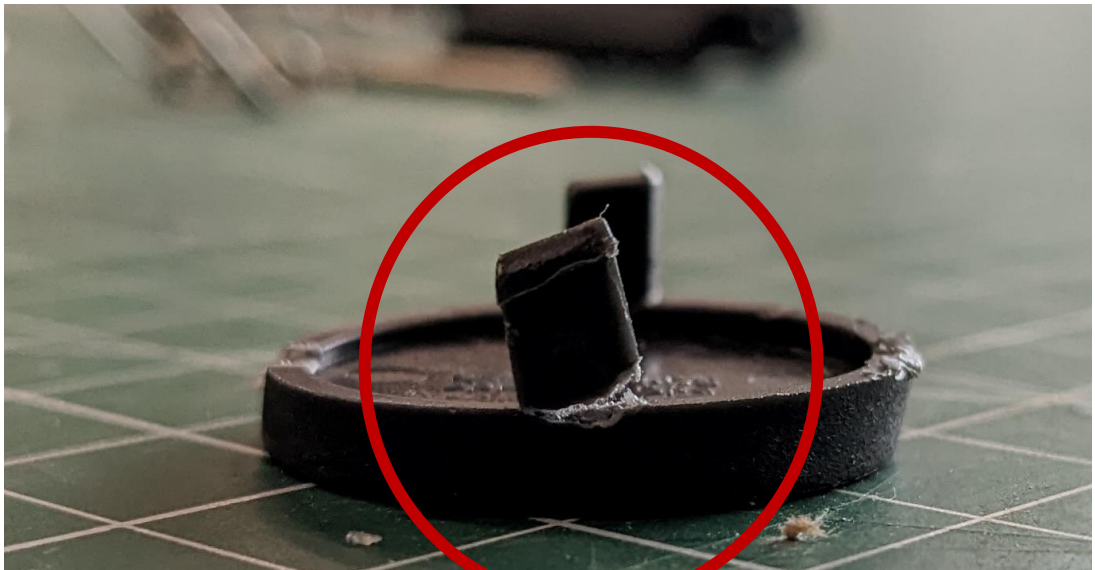
3.3.1 Findings And proposed design changes

After conducting a thorough analysis of the existing Bosch TWK5P475GB 1.7L Traditional Kettle, several design issues have been identified that impact its sustainability. In response to these issues, a series of proposed design changes have been developed with the aim of improving the kettle's environmental impact and increasing its lifespan. This section will outline the key findings from the analysis and the proposed design changes that could be implemented to improve the kettle's sustainability.

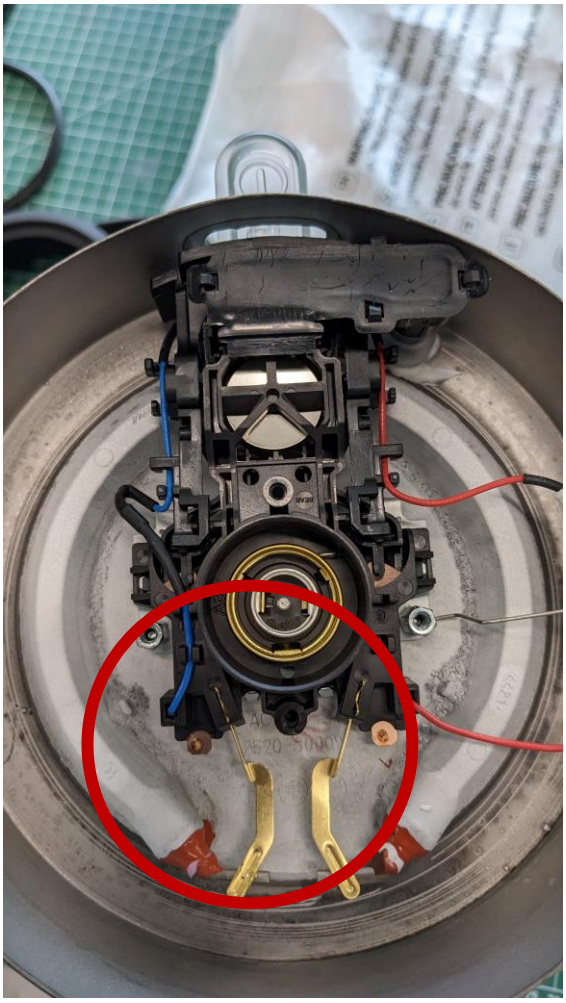
During the reverse engineering and product analysis, the first problem identified was the use of press-fit components, which made it difficult to access and repair the kettle. Once installed, the components could not be removed without damaging the legs of the parts. This made it challenging to replace or repair parts of the kettle that required attention. One sustainable solution to this problem could be the design of press-fit components that can be easily accessed and removed using simple tools without damaging the parts. This will enable easy repairs and maintenance, thus extending the lifespan of the kettle and reducing waste. Additionally, the use of biodegradable materials for the press-fit components can further enhance sustainability by reducing the environmental impact of the components at the end of their lifecycle.

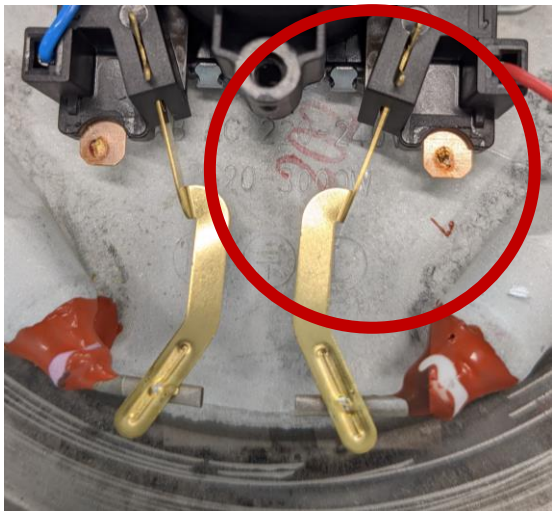




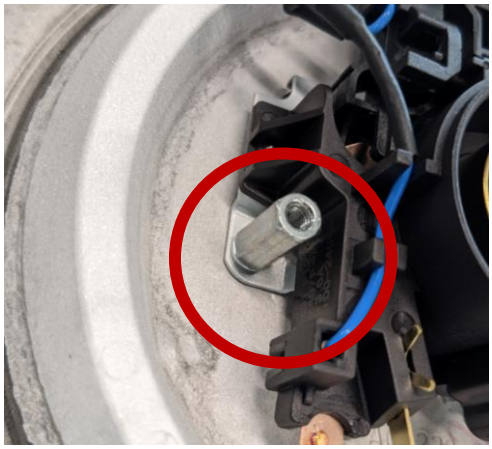


The second problem identified in the analysis of the kettle design is that the heating coil and copper strips are not removable. The heating coil seems to be welded to the container part, which makes it impossible to remove or replace. Additionally, most of the electrical wirings are also not removable. This makes repair and maintenance difficult and increases the chances of the kettle becoming obsolete and ending up in a landfill.

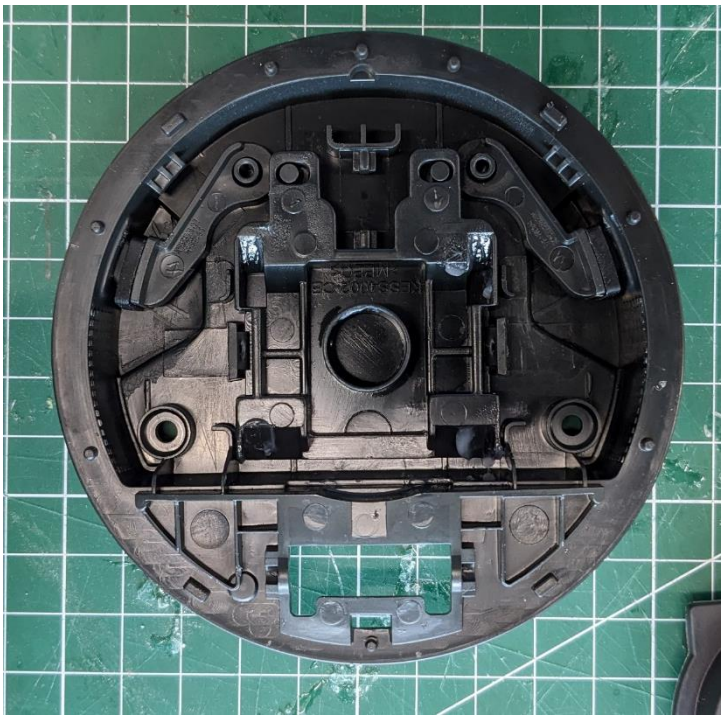


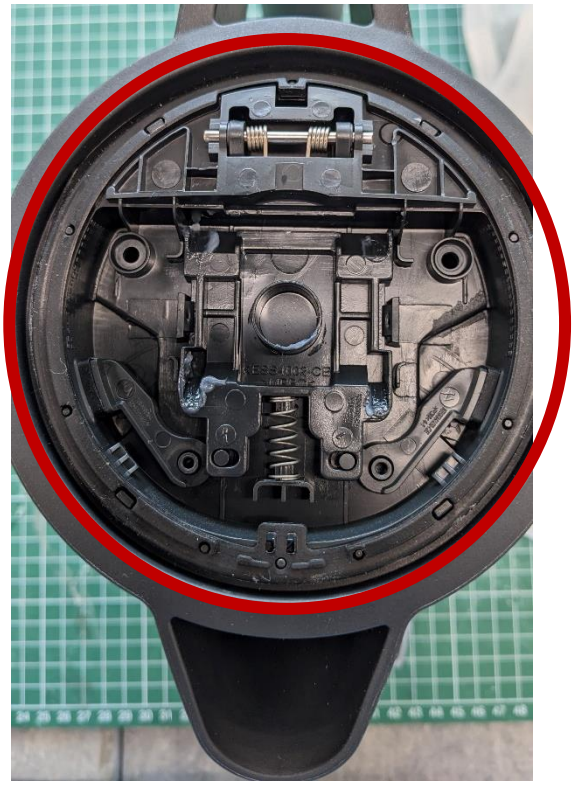


To address this issue, it is recommended to fasten these parts with screws, or to use clamps that allow for easy removal and replacement of the heating coil, copper strips, and electrical wirings. By making these components easily replaceable, the kettle can be repaired and maintained rather than discarded, ultimately reducing its environmental impact, and contributing to a circular economy.



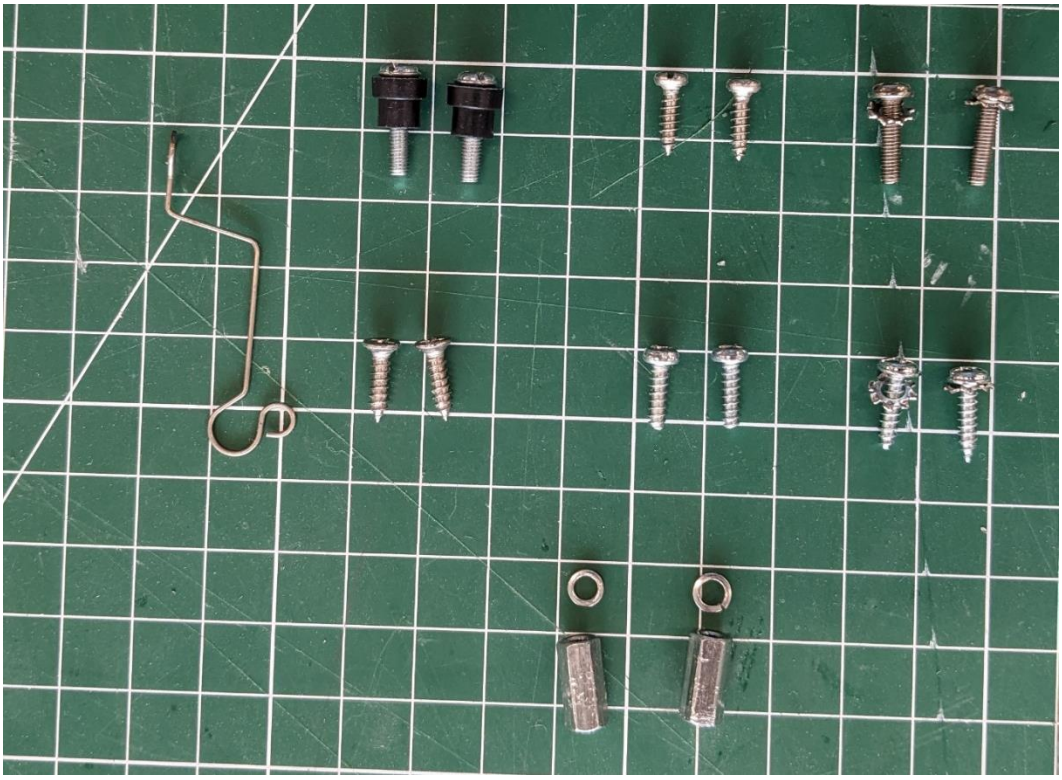
To address the difficulty of some fasteners requiring special tools for removal, slight changes in the design can be implemented. For example, the use of fasteners that can be removed with more common tools, such as screws, can be explored. This can make the design easier to maintain and repair, as users would not need to acquire specialized tools to perform basic repairs or maintenance. Additionally, simplifying the overall design and reducing the number of fasteners required can also make the product more accessible and user-friendly.





One of the other problems identified is the complicated mechanism and the high number of parts required for closing the lid. This can make the design difficult to use and maintain, as well as increasing the risk of failure due to the high number of parts that may need to be replaced if they break or become damaged. Additionally, the material selection of the current design may not be sustainable or environmentally friendly. To address these issues, proposed solutions include redesigning the lid closing mechanism to reduce the number of parts required and selecting more sustainable materials for the design. The focus should be on simplifying the mechanism while maintaining the ease of one-hand opening.

The water level indicator presents a challenge for repair as it requires special tools to remove, and the material used is not elastic and easily deforms when attempting to remove it. This makes it difficult to access and repair the indicator when necessary. Preferred solutions: Find a new mechanism to attach the water level indicator that is easier to remove and replace. Replace the current material with a more elastic and durable one.



Another identified difficulty 9with the kettle design is the use of more than eight types of fasteners that require additional tools, some of which are special types. Additionally, some screws are integrated with unique plastic parts, making disassembly and repair more difficult. To address this issue, a preferred solution would be to standardize the fasteners used in the kettle design as much as possible. By reducing the number of fastener types and using more commonly available tools, disassembly and repair of the kettle would be made easier and more accessible to the end-user.

1. Materials: Consider using durable and sustainable materials such as recycled stainless steel, aluminum or bamboo for the kettle's main body and handle. These materials can be easily recycled or upcycled after the product's end of life.
2. Accessibility: Design the kettle with easily accessible components for repair and maintenance purposes. This could involve using fasteners that can be easily removed without requiring special tools or using a modular design to facilitate component replacement.
3. Heating Coil and Copper Strips: Design the heating coil and copper strips in a way that they can be easily removed and replaced without requiring any welding. Consider using a plug-and-play mechanism that allows easy installation and replacement of these components.
4. Electrical Wiring: Use removable connectors and design the wiring in a way that it can be easily detached and reattached, without damaging any of the other components.

5. Adhesives: Use sustainable adhesives such as biodegradable and non-toxic ones that allow for easy disassembly and reuse of parts.
6. Mechanism: Simplify the mechanism for closing the lid and reduce the number of parts involved. Consider using a magnetic or spring-loaded mechanism for the lid that requires fewer parts to operate.
7. Water Level Indicator: Use a more elastic and durable material for the water level indicator that can be easily removed and reinstalled without getting deformed or damaged.
8. Fasteners: Use standard and easily accessible fasteners for the product design. Reduce the number of fastener types and avoid the use of unique and difficult to remove fasteners.
9. Screws: Use screws that can be easily removed without damaging the plastic parts they are integrated with. Consider using a snap-fit design that eliminates the need for screws altogether.
10. End-of-life: Design the kettle in a way that it can be easily disassembled and recycled or upcycled at the end of its life. Consider designing the product for a circular economy

4.0 Expert interviews

During the expert interviews, various professionals in the field of sustainable design and product development provided valuable insights and recommendations for improving the sustainability of the kettle design. The interviews covered topics such as material selection, production processes, repairability, and end-of-life considerations. The experts emphasized the importance of designing products with a circular economy in mind, which involves extending the lifespan of products through repair and recycling. They also stressed the need for more sustainable materials and production processes, as well as simplifying the design for ease of repair and disassembly. The expert recommendations played a crucial role in identifying the challenges and proposing solutions for the sustainable design of the kettle.

4.1 Analysis of expert opinions on best practices

After analysing the expert opinions on best practices, a customer-centric approach is crucial for successful product design. The design should prioritize ease of use, maintenance, and repair, as well as sustainability and durability. The use of standardized parts and materials can also make the design more efficient and cost-effective. Furthermore, experts suggest that incorporating user feedback and conducting usability testing can lead to a more successful product design. By implementing these best practices, companies can ensure that their products meet customer needs and expectations while also reducing the need for frequent repairs and replacements.

The expert interview involved individuals with experience in kettle manufacturing, cycle economy, and sustainability. The experts agreed that the findings were valid, and a complete redesign was not feasible. However, there were still practical solutions to be implemented. For instance, the issue of a complicated lid mechanism with too many parts could be addressed by redesigning it with a simplified design that does not prioritize aesthetics. The seal of the lid must still be tight and capable of boiling water in the same amount of time. The pressure of the vessel is a crucial factor that affects the boiling time of water, and it must be considered in the redesign process.

During the investigation, it was found that several electric connections in the kettle were difficult to replace due to welding or being single press-fit components. The experts interviewed explained that these connections were designed to provide a rigid and secure connection to handle the high current flow. However, it was also acknowledged that the current design made maintenance and repair challenging. In the discussion, the idea of using spring steel clips was ruled out as not an ideal option. Instead, experts suggested that fasteners and clamps could be used with enough care. A new idea that emerged was to have a

plug-and-play mechanism for the connections, which would make them easier to replace or repair if needed. This approach would help to reduce the overall cost of maintenance and improve the longevity of the product.

One of the identified problems was the presence of more than seven types of screws in the kettle design. These screws varied in length and were accompanied by washers, serving the purpose of holding different parts together, which consisted of various materials and carried different loads. During the expert interviews, it was highlighted that while the technical specifications of the screws were important for their intended function, it might be beneficial to consider standardizing the screw heads. The experts suggested that using a universal shape, such as a star or plus head, instead of rarely seen grove screws, could simplify the assembly and disassembly processes. This approach would enhance the user-friendliness of the kettle and potentially reduce maintenance and repair complexities.

During the analysis, two specific problems were identified: glued parts and the use of hard materials within the stainless-steel vessel for displaying the water level. The expert interview shed light on these issues, revealing that the glue used was thermal paste, serving as a thermal barrier for the press-fit parts. This insight highlighted the importance of this substance for the kettle's insulation. Additionally, it was discovered that the materials used in the kettle were recyclable, reflecting a positive aspect of the design. Furthermore, the expert interview revealed that the part responsible for controlling the electricity, known as the Strix, consisted of several sub-components. Secondary research indicated that this design was commonly employed in various kettle models, signifying its reliability. In terms of material choice, stainless steel was deemed suitable, and it was emphasized that any alternative materials should be BPA-free to ensure non-toxicity.

5.0 Findings and recommendations

Findings and recommendations based on our research and analysis of the kettle design. Key findings from our desk research, reverse engineering, and expert interviews are summarized. We found that there is a significant opportunity to improve the sustainability of the kettle design by incorporating circular economy principles and upcycling materials. Our recommendations are focused on improving the accessibility and repairability of the kettle, as well as designing for easy disassembly and recyclability at end-of-life.

5.1 Summary of key findings from desk research, reverse engineering, and expert interviews

The comprehensive research, reverse engineering, and expert interviews conducted for this project have yielded valuable insights and findings. Through desk research and product analysis, several design challenges were identified, including the difficulties associated with press-fit components, non-removable heating coils and copper strips, and the use of complex mechanisms and numerous parts for lid closure. The experts' opinions provided valuable guidance and suggested potential solutions. They emphasized the need for standardizing fasteners, redesigning the lid closing mechanism, and selecting more durable and sustainable materials. Additionally, the experts addressed the challenges posed by difficult-to-replace electric connections and the excessive use of screws. They proposed alternative connection methods such as fasteners and clamps and explored the possibility of implementing a plug and play mechanism. Furthermore, the experts highlighted the significance of thermal paste for insulation, the recyclability of materials used, and the importance of considering BPA-free alternatives. These findings and expert recommendations serve as a foundation for developing strategies to improve the sustainability and repairability of the kettle design.

6.0 Conclusion and future research directions

In conclusion, this research report has provided a comprehensive analysis of the existing kettle design and explored opportunities for improving its sustainability and repairability within the context of upcycling and circular economy principles. The findings from desk research, reverse engineering, and expert interviews have shed light on various design challenges and proposed potential solutions. The identified problems, such as the

presence of press-fit components, difficult-to-replace electric connections, and excessive use of screws, have highlighted the need for redesigning certain aspects of the kettle. The expert opinions have offered valuable insights and recommendations for enhancing the design, material selection, and connection methods.

Moving forward, future research should focus on implementing the recommended design changes and assessing their effectiveness in improving the sustainability and repairability of the kettle. Prototyping and testing the proposed solutions would provide valuable insights into their feasibility and practicality. Additionally, further exploration of alternative materials, such as BPA-free options, and the development of standardized fasteners and connection mechanisms would contribute to the long-term viability of the kettle design. Moreover, continued collaboration with experts, industry stakeholders, and manufacturers will facilitate the integration of sustainable practices and circular economy principles into the design and production processes. By addressing these research directions, we can strive towards creating more environmentally friendly and easily repairable kettle designs that align with the principles of upcycling and circular economy.

Through the process of identifying problems and engaging in discussions with experts, one of the key proposed solutions that emerged is the idea of standardization. By standardizing certain components of the kettle design, such as the controllers and screw heads, repairability can be significantly enhanced. This approach involves making the controllers interchangeable among different types of kettles, allowing for easier replacement and repair when needed. Similarly, by standardizing the screw heads, it becomes simpler to find compatible tools for disassembly and reassembly.

However, the concept of interchangeability extends beyond individual components. A broader perspective involves developing a design where the inner vessel and all the working parts are contained within a standard size and dimension, while the outer body becomes interchangeable. This means that customers can choose from a variety of outer shapes and aesthetics, while the inner working parts remain the same. This idea opens up a vast array of possibilities for improving the life cycle of kettles. It allows for customization and personalization while ensuring that the functional and repairable components remain consistent.

By embracing this concept of interchangeability and standardization, manufacturers can not only enhance repairability but also promote sustainability. It reduces the need for producing entirely new kettle units for aesthetic changes alone, thereby minimizing waste and resource consumption. Additionally, it empowers consumers to easily replace outer components without the complexity of dealing with the inner workings of the kettle. This approach aligns with the principles of circular economy and provides a vision for a more sustainable and user-centric approach to kettle design and manufacturing.

6.1 Summary of the research report

This research report focuses on the analysis and improvement of kettle design from a sustainability perspective, with an emphasis on upcycling and circular economy principles. The report begins by providing background information on the project and outlining its objectives and scope. It then delves into an overview of the literature related to upcycling, circular economy, electronic waste, and sustainable product design.

The report further explores the findings and recommendations derived from desk research, reverse engineering, and expert interviews. Several key problems were identified, including difficulties in accessing press-fit components, the use of less durable materials, complicated lid-closing mechanisms with numerous parts, challenges with removable electric connections, and the need for specialized tools to remove certain components. Proposed solutions involve redesigning components with fewer parts, using fasteners and clamps instead of press-fit or welded connections, standardizing screw heads, and incorporating plug-and-play mechanisms for electric connections.

Moreover, the report highlights the insights gained from expert interviews. These discussions revealed that some design choices were made for the sake of rigid and reliable connections, considering the high current flow and thermal insulation requirements. The importance of material selection, such as using recyclable materials and ensuring BPA-free options, was also emphasized.

In conclusion, the report suggests that standardization plays a crucial role in improving kettle design and repairability. By standardizing components like controllers and screw heads, repair and replacement become easier. Additionally, the concept of interchangeability, where the inner working parts are standardized while the outer body can be customized, offers significant potential for enhancing the life cycle of kettles. This approach aligns with the principles of circular economy, promoting sustainability, reducing waste, and providing consumers with customizable options.

The findings and recommendations presented in this report lay the foundation for future research directions, encouraging further exploration of design improvements and the integration of circular economy principles in kettle manufacturing.

6.2 Implications and contributions of the project to sustainable product design

The project has significant implications and contributions to sustainable product design, focusing on improving the overall sustainability of kettle design. Through the identification of problems and proposed solutions, several implications emerge:

Enhanced Product Lifespan: By prioritizing repairability and component accessibility, the project aims to extend the lifespan of kettles. Redesigning press-fit components and utilizing fasteners and clamps facilitate easier maintenance and repairs, reducing the need for premature replacements and minimizing electronic waste.

Sustainable Material Selection: The project emphasizes the importance of selecting sustainable materials. By advocating for recyclable options and considering the environmental impact of materials, the project promotes eco-friendly manufacturing practices. The aim is to create kettles that can be easily recycled and contribute to a circular economy.

Standardization and Interchangeability: Standardization plays a crucial role in the project's recommendations. By standardizing components like controllers and implementing common screw heads, the project enhances repairability and facilitates component interchangeability. This approach simplifies repairs, replacements, and upgrades, promoting a more sustainable and efficient product lifecycle.

Circular Economy Principles: The project aligns with circular economy principles by prioritizing resource efficiency and waste reduction. By incorporating upcycling techniques, advocating for component reuse, and designing for disassembly and recyclability, the project supports a closed-loop system that minimizes waste and maximizes resource utilization.

Through its practical insights and recommendations, the project contributes to the advancement of sustainable product design. By addressing key challenges and encouraging manufacturers and designers to consider the entire product lifecycle, the project aims to inspire the creation of more sustainable and environmentally responsible kettle designs.