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Bathtub Design Based on the 11R Principles of Ecological Design

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Abstract: *This study aims to explore and implement the principles of ecological design in the realm of bathtub manufacturing. By incorporating the 11R principles of ecological design, this research addresses prevalent issues such as environmental impact and the limited lifespan of bathtub products, aligning more closely with current market expectations. Employing the 11R ecological design framework, this investigation delves into the present scenario and inherent challenges faced by domestic bathtub products, utilizing market research. It further integrates this analysis with practical projects to evolve design principles and methodologies specific to bathtub products. This paper introduces innovative principles and methodologies for the ecological design of bathtubs. The application of the 11R principles to bathtub design offers diverse design strategies, significantly enhancing the market competitiveness of these products.*

Keywords: *Ecological Design; 11R Principles; Product Lifecycle; Bathtub Design*

1. Introduction

In recent years, paralleling improvements in living standards, there has been a significant uptick in young consumers' demand for bathtubs. These fixtures have transcended their traditional role as mere bathing products, evolving into artistic elements within the modern bathroom decor of younger demographics. Consequently, bathtubs have become essential in the amenities provided by hotels, guesthouses, and clubs. Key consumer concerns now center on the safety, aesthetic value, functionality, and environmental sustainability of these products. Furthermore, the long-term durability, ease of maintenance, and ecological impact of bathtub products are increasingly important considerations for many households. With the relentless advancement of the industrial sector, the majority of material industries have undergone significant changes, often at the cost of environmental degradation and resource wastage. Therefore, the incorporation of ecological design principles in bathtub design research has become imperative. This approach addresses the environmental challenges associated with material use right from the product design stage, thereby mitigating air and land pollution caused by materials that are detrimental to the environment. This shift in design philosophy not only aligns with eco-friendly practices but also meets the evolving preferences and ethical standards of modern consumers.

2. Concept of Ecological Design

2.1 Definition of Ecological Design

In 1971, Victor Papanek, an American scholar, published "Design for the Real World - Human Ecology and Social Change." In this groundbreaking work, Papanek urged designers to embrace social responsibility and championed the concept of sustainable ecological design [1]. Ecological design, also referred to as green or lifecycle design, involves integrating environmental considerations throughout the product design and development process, aiming to minimize environmental impact at every stage of the product's lifecycle. The essence of ecological design lies in addressing key issues such as energy consumption, emissions, and recycling during product manufacturing. Take paper, a ubiquitous product, as an example. It may seem environmentally benign, primarily due to its recyclability. However, closer scrutiny of its production and recycling processes uncovers that the actual "pollution" phase occurs during manufacturing. Paper production involves extensive deforestation, disrupting natural forest ecosystems and requiring significant labor and resources for transportation, processing, and refining.

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This process not only consumes vast amounts of water but also contributes to water pollution. Ecological design, therefore, seeks a harmonious balance between humans, the environment, and society, advocating for a symbiotic relationship among these elements and fostering a shared destiny with nature.

2.2 The 11R Principles of Ecological Design

Ecological design compels designers to thoroughly consider the interplay of economic, social, and environmental factors during product design. This approach meets current human needs while accounting for future generations, serving as an effective strategy for long-term nature conservation. Ecological design can enhance corporate value, foster innovation, reduce costs, improve product reputation, and increase market share. Thus, corporate development is deeply intertwined with ecological design. Many experts assert that understanding ecological aspects is crucial for developing a product's value. This understanding leads to sustainable product value, moving beyond mere aesthetic appeal. Design's primary goal is to identify and resolve problems, implying that sustainability issues require innovative thinking and new design methodologies. The 11R principles of ecological design represent such an innovative paradigm, adding value to companies and driving brand innovation. The 3R principle (Reduce, Reuse, Recycle), the cornerstone of green design, focuses on minimizing energy and resource consumption and maximizing material reuse and recycling (see Figure 1). However, the 3R approach alone is insufficient for contemporary societal demands. To more effectively safeguard the environment and reduce energy pollution, it's crucial to adopt the sustainable design route, augmented by the 11R principles of ecological design (see Figure 2). These principles, which include Reduce, Reuse, Recycle, Revalue, Repair, Re-cleaning, Redesign, Replace, Renew, Remanufacture, and Resale, should be ingrained in the mindset of every designer and engineer from the beginning, guiding ecological design from the source.

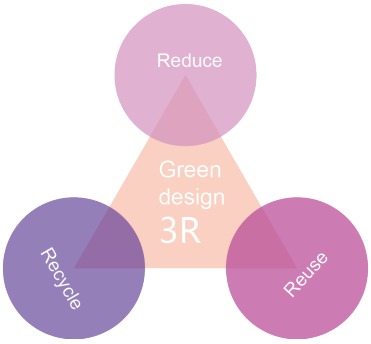

Figure 1: The 3R Principles of Green Design (Drawn by the Author)

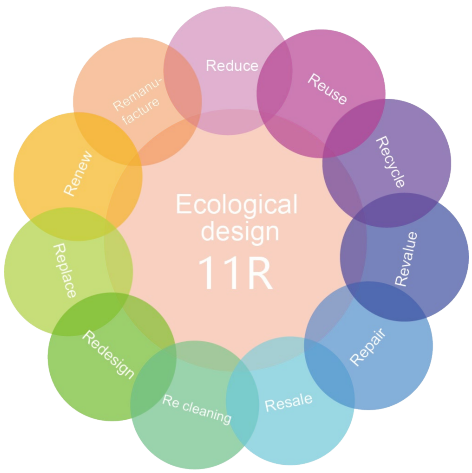

Figure 2: The 11R Principles of Ecological Design (Drawn by the Author)

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3. Current Status of Bathtub Design at Home and Abroad

3.1 Research Status of Bathtub Design Literature

Domestic and International Perspectives Presently, the scope of research on bathtub design in China is somewhat limited. A search on CNKI reveals only 48 papers specifically addressing "bathtub design." Examples include Jin Yanhong's [2] application of the fuzzy Kano model to analyze evaluation factors and design needs for domestic infant bathtubs; Lin Feng's [3] investigation into assisted bathing bathtub designs for disabled elderly individuals, offering age-friendly design solutions; Mo Zhongcai's [4] study on massage bathtub design grounded in health and wellness concepts, proposing guidelines for multifunctional massage bathtubs; Zhang Xingyu's [5] exploration of bathtub design for compact living spaces; and Sun Chunxiao's [6] research on edge-entry integrated bathtub design, focusing on accessibility for seniors. Despite these studies, there's a noticeable lack of research specifically focused on ecological design principles in bathtub design, with most research emphasizing age-friendly and ergonomic aspects. However, with growing environmental consciousness, ecological design is increasingly becoming a part of the design narrative [7]. Therefore, while research in this area is limited, it presents considerable theoretical and practical value.

3.2 Market Status of Domestic and International Bathtub Brands

Domestically, bathroom brands such as JOMOO, HEGII, ARROW, and HENGJIE primarily manufacture acrylic bathtubs, favored for their cost-effectiveness and resistance to scratching and yellowing. The production of these bathtubs involves materials like acrylic, epoxy resin, and fiberglass. Notably, fiberglass contributes to significant pollution, and epoxy resin emits strong odors, both being environmentally unfriendly materials that lead to air pollution and pose challenges in recycling post-disposal. In contrast, international bathroom brands are increasingly adopting eco-friendly artificial stone materials for bathtubs. Each brand has its unique formula, resulting in different proprietary names. For example, Kohler’s artificial stone bathtubs are marketed as Diamastone and Lyricstone, TOTO's (Japan) as Luminist, and LAUFEN’s (Germany) as Marbond composite material. This comparison highlights a clear distinction: domestic bathtub manufacturers are yet to fully embrace eco-friendly materials, while international brands prioritize sustainable ecological design, employing environmentally friendly artificial stone materials to mitigate environmental pollution.

4. Ecological Design Principles and Methods for Bathtubs

4.1 Principle of Material Reusability

In the product lifecycle, the objective is to maximize reusability, thereby controlling or extending the product’s usage period. This involves ongoing maintenance and refurbishment to ensure continued use. Design considerations should prioritize environmental impact, with an emphasis on enhancing product quality to extend its lifecycle and minimize ecological damage. The first consideration is durability, which involves elevating quality and standards. Victor Papanek, in "Design for the Real World," stresses that “good design equates to high quality.” This is particularly crucial for products like outdoor camping and mountaineering gear, where quality directly impacts safety. Durability and quality are intrinsically linked; a product lacking in quality cannot be durable. The second consideration is the reusability of materials. For bathtubs, this includes the safety, eco-friendliness, and recyclability of the materials used. The aim is to minimize material consumption and production costs by utilizing recyclable, environmentally friendly materials such as ceramic particles and marble powder. This approach avoids environmentally harmful materials, reduces the use of scarce resources, and eases manufacturing, processing, and recycling processes. Bathtubs in the market are primarily made from materials like acrylic, wood, marble, cast iron, and artificial stone, with artificial stone being an eco-friendly option due to its malleability, ease of processing, wear resistance, safety, and stability, aligning well with the principles of ecological design.

4.2 Principle of Functional Recyclability

During the design process of bathtubs, considering technological advancements and potential updates, the design should account for future repairs or upgrades, enabling easy and quick component repairs or replacements. To facilitate reparability, several key aspects should be considered: (1)

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Standardization of components, aiming to minimize the diversity in sizes and specifications within a product category to achieve interchangeability among different products; (2) Modular design, akin to car battery modules, where a single faulty module can be replaced without needing to replace the entire battery; (3) Ease of disassembly and assembly, ensuring quick and efficient part separation to improve material recycling and cleaning processes. The more cumbersome the disassembly, the greater the labor time and cost. Therefore, achieving a universal interface and modular design is essential, similar to the memory slot design in computer CPUs, which allows for easy assembly tailored to varying memory size requirements.

4.3 Principle of Reduction in Design

The principle of reduction in design emphasizes minimizing emissions, input materials, size, production processes, and adhering to minimalism throughout the design and production stages. This approach aims to curb waste emissions, conserve resources, and elevate the quality of both design and production, aligning with the ethos of sustainable design. As one of Dieter Rams' tenets for Braun's design suggests, "Good design is as little design as possible" [8]. This concept of simplicity, a key aspect of design reduction, involves stripping away superfluous elements. In bathtub design, this principle translates to a minimalist style, eliminating unnecessary lines and features, and using minimal material to fulfill functional needs. It also entails using lighter materials to reduce transportation and installation costs, and opting for compact designs to minimize spatial footprint.

4.4 Principle of Re-cleaning in Products

Re-cleaning in product design goes beyond just ensuring easy removal of surface dirt; it also encompasses the ease of disassembling, cleaning, and recycling post-use. By reducing excessive decorative elements, products can have simpler, more stain-resistant, and scratch-resistant surfaces. Bathtubs, prone to staining, can become labor-intensive to clean over time. An easy-clean surface treatment can effectively mitigate the issue of residual stains, enhancing user convenience and maintenance efficiency.

4.5 Principle of Re-evaluation in Design

Re-evaluation in design involves a critical reassessment of the processes used to transform nature in order to improve living environments. This entails refining design methods to enhance product quality, user experience, and aesthetic appeal, while avoiding over-design that leads to environmental degradation. In the context of bathtub design, this principle suggests retaining the essence of the original design with minimal yet thoughtful modifications. The goal is to uphold minimalism and comply with standards, ensuring that the revised design is more user-centric. For example, minor local adjustments, while keeping the bathtub's general outline intact, can reflect the principles of ecological design.

4.6 Principle of Replaceable Accessories

In bathtub design, product replacement can be necessitated by natural wear or accidental damage. To minimize waste from such instances, designs should incorporate easily replaceable components, allowing for quick, cost-effective replacement. This approach maximizes the utility of the bathtub and prolongs its lifecycle. For instance, if a bathtub faucet is damaged, only the faucet should need replacement, not the entire unit. This principle also applies to components like drain and overflow outlets, which should be repairable or replaceable as needed. Hence, a balance between resource conservation, cost management, and pollution control is achieved by establishing an efficient recycling service mechanism, facilitating easier disassembly and material categorization [9].

5. Application of Ecological Design in Bathtub Products

5.1 Analysis of Needs and Functionality

Consumers of bathtub products prioritize both quality and functionality, seeking items that cater to their specific needs. A primary consideration is aesthetics; bathtubs with artful designs, such as oval shapes (as illustrated in Figure 3), not only harmonize with the surrounding environment but also

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minimize the risk of injury and simplify cleaning processes. Features like ultra-thin edges enhance the interior spaciousness of the bathtub. Practicality is another crucial aspect. Given that the primary function of a bathtub is for bathing, features that augment this experience are valuable. For instance, integrating a towel rack within the bathtub design (as depicted in Figure 4) obviates the need for additional towel racks, thus providing convenience and cost savings. Comfort is also a key factor in bathtub design. Bathtubs with ergonomically designed stepped angles at the bottom and top offer a more comfortable bathing experience, accommodating various reclining positions. Finally, ease of cleaning is essential. Minimalist lines in bathtub design (as shown in Figure 5) meet users' preferences for straightforward maintenance, effectively reducing cleaning challenges posed by intricate gaps and steps. These considerations exemplify the application of ecological design principles, prioritizing user-centric features while maintaining environmental and aesthetic sensibilities.

Figure 3: Design Concept (Oval Shape)

Figure 4: Design Concept (Towel Hanging Feature)

5.2 Utilization of Recyclable Materials in Bathtub Design

At the heart of bathtub product design lies the principle of ecological design, with a strong emphasis on using recyclable materials. Bathtubs are crafted from sustainable materials such as ceramics, resin, and aluminum powder, which not only reduces material costs but also simplifies the production process. Furthermore, the design incorporates a modular approach, embracing the concept of replaceability central to ecological design. This encompasses considerations of module independence, interchangeability, and universality [10], allowing for greater flexibility and customization. Consumers are offered the option to purchase either a basic, empty tub or a more feature-rich bathtub equipped with integrated towel racks and shelving. The accessories are designed to be adaptable, offering customization in both shape and color. Additionally, the bathtub sizes are tailored to cater to diverse requirements, available in four distinct dimensions: 1500mm×750mm×530mm, 1600mm× 750mm× 530mm, 1700mm×750mm×530mm, and 1800mm×750mm×530mm. This approach to design not only aligns with ecological principles but also enhances customer satisfaction by providing a range of personalized choices.

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Figure 5: Design Concept (Usage Scenario)

6. Conclusion

Ecological design embodies a pivotal trend in contemporary societal progress and constitutes an essential aspect of corporate social responsibility. The integration of ecological design principles into bathtub product design presents a strategic approach to prolonging the lifespan of bathtubs. This method not only assures a comfortable bathing experience for consumers but also confronts the environmental challenges commonly associated with traditional acrylic bathtubs. It steers businesses towards innovative product enhancements and offers a cost-effective solution in production processes. By embracing ecological design, companies can align their operations with environmental stewardship while delivering superior products that meet the evolving needs and values of modern society.

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