

Transforming Plastic Cup Waste Into A Translucent Lamp Design: An Innovative Approach to Sustainable Design

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ABSTRACT

The spread of contemporary drinks among the public has led to an increase in the consumption of polypropylene (PP) plastic cup packaging, which is considered more practical and profitable. However, plastic cup packaging waste is more complicated or rarely recycled because it is not biodegradable. This research aims to reuse PP plastic waste as a valuable material to extend product life. The methods used in this research are experiment, Material Driven Design (MDD), and SCAMPER. The physical properties of recycled PP material are that it absorbs light, is translucent, is hard, has a smooth surface, does not conduct heat, and does not melt when exposed to sunlight. Based on these unique properties, the table lamp was designed to optimally expose the material and provide a different experience for the user.

Keywords: Plastic Cup, Polypropylene, Recycle, Translucent, Material Driven Design, SCAMPER

INTRODUCTION

Indonesian society must be connected to the use of plastic in everyday life. The public often uses plastic because it is easy to obtain, durable, waterproof, and relatively cheap. It is undeniable that the development of plastic is high-speed to dominate the economic sector in producing and distributing various products, especially plastic packaging. The emergence of plastic as an alternative in packaging is often used in the beverage business as disposable plastic cup packaging. The development of the beverage business is influenced by the emergence of contemporary beverage trends that can change people's consumptive patterns.

The beverage business offers practicality and convenience by serving contemporary drinks in plastic cups. Sales of beverages packaged in plastic cups with screen printing have grown by 14% yearly (Laurencia in Putra, 2020). If plastic cups in one coffee shop produce 200 pcs every day and end up in the trash, it will become an unresolved environmental problem. Café activities are dominated by plastic cup waste with Polypropylene (from now on referred to as PP) as much as 22.53 kg for 30 days (Rahayu Jati et al., 2021). Plastic waste will continue to increase based on the number of consumers and the growing beverage business.

Yogyakarta generated 25.82% of plastic waste in 2022 (SIPSN, 2022). Plastic waste will pollute the surrounding environment and seawater, threatening living things because it is not easily decomposed. The problem of plastic waste can be solved with the concept of a circular economy that applies the recycling process (recycle) through an experimental stage to extend the product's life. Experiments were conducted to find a suitable composition so that PP recycled materials can achieve superior characteristics. Not much has been done based on previous research on developing translucent levels through a material approach. This research uses the Material Driven Design method to examine user experience related to materials and SCAMPER to develop product ideas.

LITERATURE REVIEW

A. Material Driven Design

The Material Driven Design method has a four-step process, which is to (1) Understanding Material: Technical dan Experiential Characterization, is an analysis conducted by recognizing the characteristics and quality of user experience related to materials. (2) Creating Materials Experience Vision is to build a vision of the material experience of the product by paying attention to the characteristics of the material to find the connection between the material, the product, and the user. (3) Manifesting Materials Experience Patterns is to analyze the application of materials in products by paying attention to material properties. (4) Creating Material/ Product Concepts aims to design a product concept that is in accordance with the results of the analysis from the previous step (Karana et al., 2015).

B. Current Beverage Trends

Indonesia has a rapidly growing beverage business. Contemporary drinks based on tea, milk, or coffee are in great demand from the public to become a trend and promising business opportunities. For example, The Kopi Nusantara Community describes around 3,000 coffee shops throughout Yogyakarta (Pradana et al., 2022). The results of a survey in 2022 of 440 respondents, dominated by 37% of respondents who visited more than two times a month (Goodstats, 2022). Consequently, the consumption of plastic cups is increasing because the beverage business offers practicality and convenience to consumers by providing drinks in plastic cups. These plastic cups are made from polypropylene (PP), which is transparent, not easily broken, easily closed with a lid sealer, and cheaper than PET plastic.

C. Polypropylene (PP)

Polypropylene (PP), a thermoplastic polymer, is a unique material that cannot be biodegraded. It softens when heated to a specific temperature and hardens when cooled, a process that can be repeated. PP, coded as number 5, is safe for recycling due to its EPA Safer Chemical Ingredients classification. With a melting point of 160-171°C, PP offers promising potential for reuse (Sari, 2019).

D. Plastic Waste

The development of the beverage business could increase plastic packaging production. The number of plastic packaging industries in Indonesia is around 925 companies, with a total production of 4.68% million tons (the Ministry of Industry, 2017). As a producer, the packaging industry contributes to plastic waste that will end up in landfills. Even though the roadmap regulation is implemented to help reduce the irresponsible behavior of consumers and producers in carrying out their consumption activities (P75 of 2019 Waste Roadmap, 2019), plastic waste is still increasing. However, the transition from a linear economy to a circular economy holds promise as one of the solutions to the environmental crisis, offering a sustainable and efficient way to manage plastic waste.

E. Circular Economy

Circular economy carries the concept of “sustainability,” which positively impacts the environment. The circular economy model is designed from product, use, end of life, and remanufacture (Masruroh et al., 2022). Production or consumption waste that no longer has value in the circular economy is converted into products that can be reused. The circular economy is circular with the 5R principle, namely Reduce, Reuse, Recycle, Recovery, and Repair (Sarofah, 2022).

The circular economy focuses more on restorative economic activities or extending product life and regenerative by prioritizing value (Masruroh et al., 2022). A circular economy is implemented by several business actors, including Olyplast, Pelita Mekar Semesta, Ecolabo, Mortier, Robries, and Paste Laboratory.

F. Translucent Properties of Materials

Materials with transparent, translucent, and opaque properties differ in how they receive light. The definition of transparency is that light can pass through the material without scattering because the surface is clear. At the same time, materials with opaque properties do not allow light to spread or receive light. Materials with translucent properties can absorb or diffuse light, creating a hazy appearance. Translucent is the property of translucent objects when shiny and illuminated from behind or inside the object (Fleming et al., 2004).



Image 1 Differences in Light Intensity on Materials.
(Source: mathsisfun.com, 2022)

METHODOLOGY

This research method uses a material exploration approach with quantitative methods. The method used is as follows.

A. Research Method

- Literature Study
- Field Study: Surveying PP plastic cup waste availability and conditions in several franchises, coffee shops, and cafes
- Material Experimentation: aims to find ideas for using recycled PP plastic cup waste materials. The experiments used moulding techniques, press techniques, and gluing techniques.
- Material Driven Design (MDD): aims to determine the user experience of a new material (Karana et al., 2015). Experimental results will be analyzed through hands-on interaction with respondents.

B. Design Method

- SCAMPER is a brainstorming technique for developing product design ideas. It consists of seven topics: Substitute, Combine, Adapt, Modify, Put to Other Uses, Eliminate, and Reverse.
- Sketch is the initial idea as an exploration medium that provides an overview of the product development process.
- Model Study, Mock-up, and Prototype aims to realize the concept or sketch into a physical model using similar materials with a scale of 1:1.

RESULT & DISCUSSION

1. Experimentation and Exploration Process

The experimental stage starts with collecting, sorting, washing, drying, and chopping PP plastic glass waste to facilitate recycling. The experimental process aims to find the right temperature, time, and mass composition to achieve the maximum level of translucency in the material. The following are the results of the experiments that have been carried out:

- Experimental results using 1000 watt/hour microwave with a mixture of screen printed and transparent plastic cups. Sample 1 used a chopping

mass of 20.8 grams, a melting temperature of 250°C, and a time of 20 minutes. Sample 1 uses a silicone mold so that it cannot be pressed, has a rough texture, and tends to be hollow (void). Sample 4 uses a stainless mold and transparent shreds with a variable composition of the first exhaustion of 10.5 grams; 250°C; 15 minutes; second 9.9 grams; 200°C; 15 minutes; third 6.6 grams; 200°C; 13 minutes.

- Experimental results using a toaster oven that has no temperature control by melting transparent plastic shreds for volume shape exploration. Sample 8 used a stainless mold and variable composition for the first meeting of 30 grams, 5 minutes, the second 10 grams, and 7 minutes. Sample 12 used a 600-watt/hour microwave with an aluminum mold. The variable composition for the first meeting was 25 grams, 200°C, 20 minutes; the second was 25 grams, 200°C, 15 minutes; and the third was 10 grams, 200°C, 10 minutes.

The exploration stage serves to determine the capabilities of the material by applying gluing techniques and textures that can be developed.

- The results of the exploration were used to try alternatives in the manufacturing and production process if needed. Texture exploration by melting plastic shreds that are not pressed so that they have a tactile texture like crystals (uneven) and uneven. Meanwhile, the gluing process uses solder to connect two materials with different shapes. The bowl-shaped material is glued to the slab-shaped part.

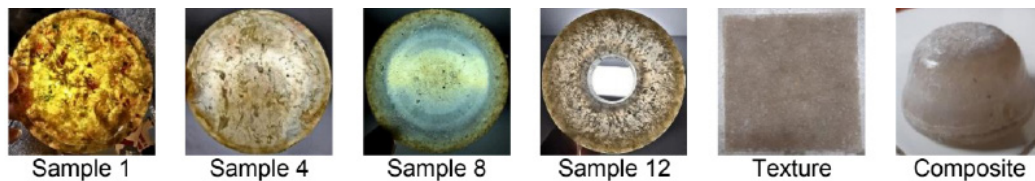


Image 2 Samples of Experimentation & Exploration Results. (Source: Christina et al., 2024)

2. Translucent Testing of Materials

Samples are tested for translucency using a flashlight shining from the bottom across the sample's surface. The light shining on the sample can reveal the texture produced on the material. The sample has gone through a finishing stage to smooth out any rough surfaces. The test results are opaque, soft, yet translucent. The visual texture on sample 1 is terrazzo-like, samples 4, 8, and 12, and the gluing sample is marble-like, and the texture sample is Himalayan salt/crystal-like.

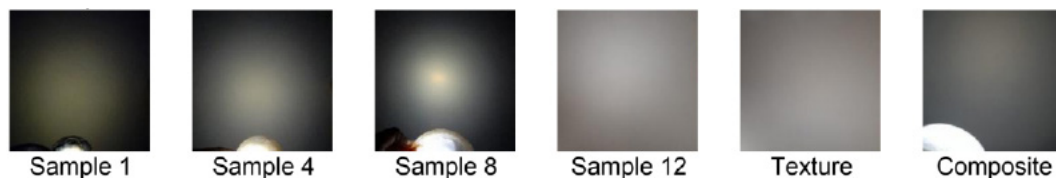


Image 3 Material Translucent Testing Results. (Source: Christina et al., 2024)

3. Material Driven Design Method Analysis

PP recycled materials were analyzed using the Material Driven Design method (Karana et al., 2015; Martono et al., 2022).

- The first step is recognizing the technical and experiential characteristics of the PP material. The data was obtained from a questionnaire with ten respondents including: 20-25 years old and above, workers, and students, as follows 1) Sensorial: sensations that are felt through the senses by respondents are hard-surface (10), smooth (7), reflective (6), warm (5), inelastic (10), transparent (5), stiff (10), intense (10), and light (10). 2) Affective: emotions or feelings that arise when interacting with materials. The most selected keywords include interested (6), like (3), satisfied (4), curious (6), and funny (3). 3) Interpretive: the meaning or perspective of the user that is important to consider so that the product achieves the meaning that must be developed or avoided. The most selected keywords are unique (4), creative (4), simple (3), resin-like (4), and marble-like (3). 4) Performative: what the material is intended to do or know. Respondents interacted with the material, such as tapping the sample on the table and fingers, rubbing, shining the sample, and pointing the sample at the light.
- The second step is to envision the material experience of a product, drawing upon the unique characteristics of PP recycled material. This material, with its translucent properties, can serve as a captivating ‘point of interest’ in a contemporary design. Moreover, the unavoidable impurities in recycled PP material create a distinct, unrepeatable pattern, eliminating the need for additional color. This intriguing aspect of the material resonates with the Japanese art concept of wabi-sabi, which celebrates imperfection as a form of beauty.
- The third step involves exploring the potential applications of materials in various products, considering their unique opportunities. PP recycled material, with its diverse characteristics, presents numerous opportunities for use in interior design, home decor, lighting, and furniture.

Table 1 Characteristics of PP Recycled Materials. (Source: Christina et al., 2024)

Physics	Light properties: the presence of light that propagates straight and can be absorbed (absorption), and translucent.
	Tactile texture: smooth and rough. Visual texture: uneven (crystal), marble
	Temperature: does not conduct heat, does not melt quickly when exposed to sunlight
Mechanical	The Material can shrink when exposed to hot temperatures The Material expands when exposed to cold temperatures

Manufacturing	Cutting capable: can be cut by saw and CNC
	Finishing capability: can be sanded
	Molding capability: container forming, volume, embossing
	Bonding capability: can be bonded using solder

- The fourth step aims to design a suitable product according to its characteristics. Based on the previous results of MDD, it is preferable to design lamps and luminary product categories for indoor applications, such as table lamps. Moreover, due to the first step results, the material is strong enough to suit products that do not perform heavy tasks and require a certain level of translucency. Next, the development of design concepts was using the SCAMPER method.

4. SCAMPER

The SCAMPER method generates design ideas in the form of sketches by developing similar products. The following are sketches of design ideas from the long journey of applying the SCAMPER method.

Sketches 1, 2, and 3 are selected through an assessment questionnaire by potential target users based on the product design concept. The assessment of the sketches obtained results on a scale of 1-5 (very dissatisfied-very satisfied) chosen by 18 respondents via Google Form. Sketches that were mostly chosen (very satisfied) were sketch 1 with 13 respondents, sketch 2 received 9 respondents, and sketch 3 was chosen by 8 respondents.

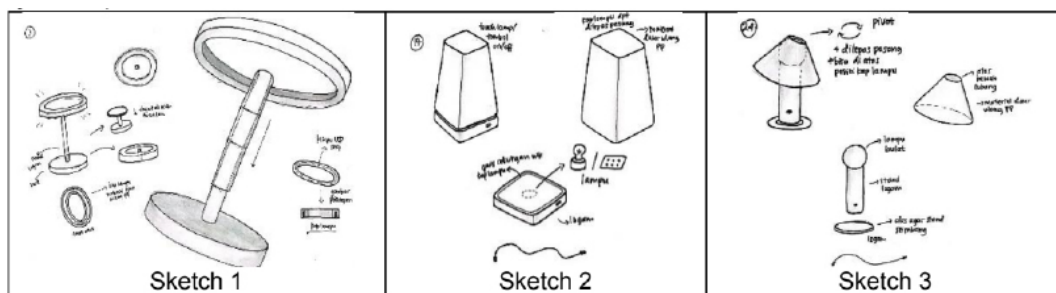


Image 4 Sketch of Table Lamp Design (Source: Christina et al., 2024)

5. Freeze Design

Freeze design is the selected design from the iterated sketches of ideas. The product has two series divided into two concepts: “Little Light” and “Scylizo”. The following is the freeze design of the product to be produced:

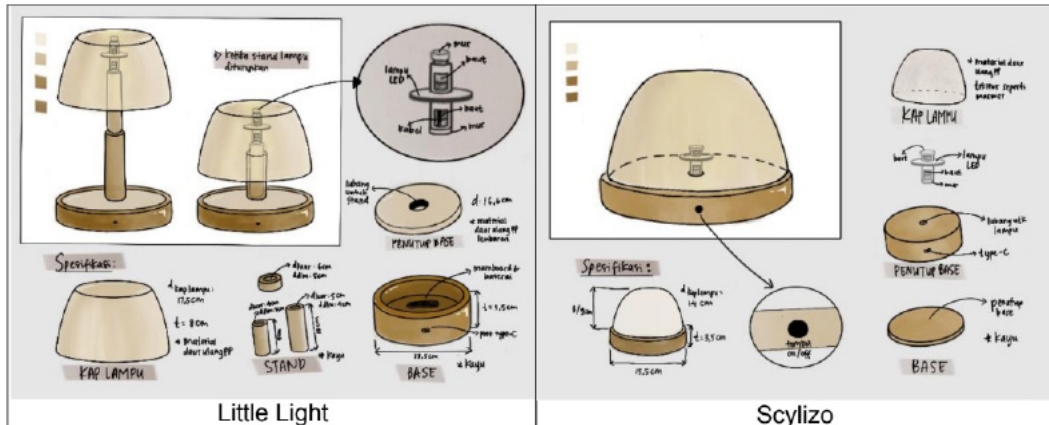


Image 5 Freeze Design of Table Lamps. (Source: Christina et al., 2024)

6. Prototype

The following prototypes were the final design that fulfilled the design criteria. The product consists of two series: “Little Light” for the first series, which is inspired by the shape of contemporary style, and “Scylizo” for the second series, which is inspired by the shape of jellyfish to raise the issue of plastic waste that damages the ecosystem of living things such as jellyfish in the sea.



Image 6 Prototype. (Source: Christina et al., 2024)

CONCLUSIONS

PP recycled material's experimentation and exploration phase can achieve the best translucent level in light penetrating the material and brownish white. The thickness and density of the PP recycled material dramatically affect the translucent result. The Material Driven Design analysis results found that PP recycled material has a “point of interest” or visual interest. The concept of wabi-sabi is raised because PP recycled material is not protected from dirt and murky colors but has a unique style that does not require additional colors. The results of the material's light beam test can propagate straight and produce soft light so that the product leads to a table lamp that is flexible in placement. The lampshade from PP recycled material can be used during studying or leisure activities. The product consists of two series, namely Little Light for the first series, which is inspired by the shape of contemporary style, and Scylizo for the second series, which is inspired by the

shape of jellyfish from the results of experiments and raises the issue of plastic waste that damages the ecosystem of living things such as jellyfish in the sea. This research can still be developed further by dividing the PP plastic waste mass into several melts so that the melt is evenly distributed at the same temperature, and different results can be obtained.

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