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Customer Preference of Recycled Plastic Products

Pei-Ju Lin and Jun-Yu Yang

The Department of Commercial Design, National Taichung University of Science and Technology, No.129, Sec.3, Sanmin Rd, North Dist, 404 Taichung, Taiwan

ABSTRACT

The circular economy of recycled plastics is gradually emerging. Its objective is to reduce the production of new plastics, design products with recycled plastics according to the thermoplastic characteristics of plastics, classify, wash, dry, finely shred, and then melt and remanufacture waste plastics to reshape the appearance and function of products. In this study, consumers' acceptance, cognition, and preference for recycled plastic products were explored based on the image these products carry. A total of 11 commercially available recycled plastic products were collected, which were respectively made of propylene (PP), high/low-density polyethylene (HDPE/LDPE), and poly (ethylene glycol-co-1,4-cyclohexanedimethanol terephthalate) (PETG), and shaped by the injection moulding machine, compressor, tablet press, and 3D printing. These adjectives were used for the survey of 100 subjects for their evaluation of recycled plastic products. The consumers' preference for the material of the recycled plastic products is in the order of HDPE/LDPE > PETG > PP. In addition, the evaluation of those using moulds in the manufacturing process is high, which can achieve a better product image and win consumer preferences. In the sample products of this study, a recycled watch strap is made of LDPE material using the injection moulding machine.

Keywords: Recycled plastics, Thermoplasticity, PE, PP, PETG, Customer preference

RESEARCH OBJECTIVES AND MOTIVATIONS

In recent years, many designers have used recycled waste plastics in new products, contributing to the circular economy in which resources are infinitely recycled. In literature related to the waste plastic recycling process, such as the development of a plastic shredder (Ekman, 2018), the thermoplastic characteristics of plastics are used to make recycled products that eventually return to consumers. In this study, the discussion of plastic properties and process technology is extended. A total of 11 sample products are considered from a collection of commercially available recycled plastic products, and a survey on the image of these products is conducted to determine consumers' perceptions and preferences of recycled plastic products to facilitate the development of manufacturing technology for recycled plastics.

LITERATURE REVIEW

(1) Injection moulding: More than 30% of plastic handicrafts are made by injection moulding. The injection moulding machine heats and melts the

plastic and then extrudes it. Singh (2016) found that temperature, pressure generated during injection, and injection speed affect the tensile strength of plastics. This injection moulding technology is suitable for products with high demand and repeatability, making it possible to fully exploit the repeated usage of moulds, leading to fast production and high precision. (2) Compression Machine: The compression machine uses the concept of oven heating technology, in which plastics are melted and compressed into large-scale moulds. The principle is to compress the shredded plastics by heat and pressure. However, the plastic becomes fluid or granular in shape during the compression process, and the manufacturing process is time-consuming and only suitable for large-scale products (Gordeev, 2019). (3) Extrusion Machine: Based on the principle of industrial single-screw extruder, the waste plastics are melted and extruded. The plastics are transferred to the heating tube through the screw rod, and then extruded after being melted in the heating tube. The viscosity of the material, design of the screw, and speed of the screw affect the performance of plastic extrusion (Abeykoon et al., 2021). (4) Sheet Machine:The sheet machine shapes the products by heating and extrusion. The extrusion duration affects the thickness of the sheet. The longer the extrusion duration, the thinner the sheet will be (Wongsangnoi et al., 2021). (5) 3D Printing: 3D printing is often used in auto parts, medical equipment, toys, etc. A plastic shredder is used to smash the waste plastics into small pieces, which are then melted and extruded into thin wires through a plastic extruder. The thin wires can be used as the raw material for 3D printing, which is sent to a 3D printer and converted into a valuable product (Mikula et al., 2021).

RESEARCH METHOD AND PROCEDURE

First, 11 commercially available recycled plastic products were collected as samples and analysed.Finally, the survey results were summarised and analysed to understand the subjects' cognition of recycled products and product preferences. The 5-point Likert scale was used to measure the evaluation of 100 subjects on the perceptual image of recycled plastic products.

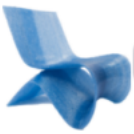
Sample Collection and Classification

In this study, recycled products sold in online and offline stores were collected, and 11 main samples with relatively good sales volume were selected, the raw materials of which were respectively PP, HDPE/LDPE, and PETG. In the subsequent analysis of this study, HDPE and LDPE were treated as PE and analysed as the same category, the moulding methods of which include using injection moulding machine, compression machine, sheet machine, and 3D printing. The practice of using moulds in the manufacturing process or not is treated as an important factor. In addition, to avoid the subjects being influenced by other factors during their evaluation of the products, the background of the products is removed, as shown in Table 1.

Survey on Cognition and Preference for Recycled Plastic Products

To analyse the consumers' understanding of plastic recycling, as well as their acceptance and preference for recycled plastic products, the survey

Table 1. Recycled plastic product samples and classification results.

	A1	A2	A3	B1	B2
					
	MANDIN Recycled Plastic Skateboard Deck	Precious Plastic Estonia Planetary Clock	PlaatjesMakers Plates	Precios Plastic Headquarters-made	Brothers Make-made
Plastic type	PP	PP	PP	HDPE	HDPE
Moulding method	Injection moulding	Compression	Injection moulding	Sheet machine	Sheet machine
Usage of moulds	Yes	Yes	Yes	No	No
	B3	B4	C1	C2	C3	D
						
	Space Available & Peggy Gou Peggy Chair	Recycled plastic watch Aqua by WALTIC	Van Plestik Wave Table	Van Plestik Wavy Chair	91-92 1st Century A.D. 02	HI JAC dog leash
Plastic type	HDPE	LDPE	PETG	PETG	PETG	HDPE
Moulding method	Sheet machine	Injection moulding	3D	3D	3D	Compression
Usage of moulds	No	Yes	No	No	No	No

was focused on understanding the basic cognition of the subjects on plastic recycling, such as whether they have the basic understanding of plastic recycling, accept recycled products, and understand the existing plastic recycling mechanisms in Taiwan. The survey investigated their preference for recycled products to confirm the acceptance of recycled plastic products in the consumer market. The survey data obtained was then analysed to establish the correlation between the perceptual adjectives and the elements of the product to determine the needs of the subjects and preferred design features and understand the preferences of consumers.

RESULT ANALYSIS AND DISCUSSION

Difference in Cognition Due to Previous Purchase of Recycled Products

Regression analysis was used to analyse the influence of consumers' preferences on purchasing intention and cognition of recycled products. The

Table 2. Analysis of difference in willingness to purchase recycled products and cognition.

Mode	Unstandardised coefficients		Standardised coefficients	t-value	Significance
	Estimated B value	Standard error	Beta distribution		
Repulsion to using recycled plastic products	−.189	.070	−.320	−2.704	.008
Willingness to purchase recycled plastic products	.165	.074	.263	2.220	.029
Understanding of plastic recycling and manufacturing	−.187	.049	−.422	−3.807	.000
Understanding of existing plastic recycling mechanisms in Taiwan	−.031	.049	−.069	−.626	.533

different modes, including repulsion to using recycled plastic products, willingness to purchase recycled plastic products, and understanding of plastic recycling and manufacturing process, all had a significance level <0.05, indicating that the 100 subjects aged between 25 and 55 had a certain level of understanding of the manufacturing process of recycled plastic products (table 2), as well as no repulsion to using recycled plastic products and the willingness to purchase recycled plastic products. However, many consumers were still unclear regarding the plastic recycling process.

Consumers' Preference for Recycled Products

Table 3 (A) shows the quantitative analysis of consumers' preference for recycled products. The three types of plastics analysed include PP, HDPE-/LDPE, and PETG. As shown by the scores, the consumers' preference is in the order of HDPE/LDPE (0.24) > PETG (0.23) > PP (−0.17). Moreover, it is shown that consumers prefer products made using moulds. The larger the value of the multiple correlation coefficient, the more linear is the relationship between the elements and variables. Therefore, in comparison to mould use, the plastic used in recycled products had a larger influence on consumers' preferences.

In Table 3 (B) and Table 3 (C). The scores indicate that consumers' preference follows the order of HDPE/LDPE > PETG > PP, and products made using moulds have relatively high evaluations. The partial correlation coefficients of plastic and mould use were calculated and compared, which revealed that the influence of plastic type on consumers' preference for the recycled plastic products was larger than that of mould usage during the manufacturing process.

Table 3. Consumers' preference for recycled products in three perspectives.

A Consumers' preference for recycled products				B Influence of integrated factor of recycled products on consumers' preference		C Influence of gorgeous factor of recycled products on consumers' preference	
Item	**Category**	**Score**	**Partial correlation coefficient**	**Score**	**Partial correlation coefficient**	**Score**	**Partial correlation coefficient**
Plastic	PP	−0.17	0.60	−1.34	0.63	−0.24	0.58
	H/LDPE	0.24		1.23		0.67	
	PETG	0.23		0.33		0.55	
Mould use	Yes	0.18	0.49	0.89	0.59	0.56	0.44
	No	−0.13		−0.67		−0.38	
Constant		3.32		1.58603E-17		7.14286E-07	
Multiple correlation coefficient = 0.60				0.64		0.59	
Coefficient of determination (Square of multiple correlation coefficient) = 0.36				0.41		0.35	

CONCLUSION

Consumers are less aware of the plastic recycling process in their daily life. To strengthen environmental protection measures, the government needs to actively promote plastic recycling. In addition, it is found that PE, including the HDPE and LDPE analysed in this study, and products made with moulds are preferred by consumers. Among the sample products, a recycled watch belt is made of LDPE using injection moulding. Further comparison reveals that the plastic material is a key factor influencing consumers' choice of recycled products, which should be the main design element. The results of this study not only help understand the consumers' acceptance and preference for recycled plastic products but also reveal the plastic type that has a relatively large influence. In the linear consumption model of the economy, energy sources are developed, manufactured, used, and discarded on a large scale, which causes environmental pollution and energy depletion. To facilitate energy recycling, the perceptual image of recycled plastic products is explored to discuss the feasibility of recycled plastic products. The analysis results can be further applied to the design-making in the design of recycled plastic products in the future.

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