Guideline for Green Design of Printers and Multi-function Printers

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Abstract. This paper regulates the purposes and basic principles of green design of printers and multi-function printers, and provides the green design requirements and procedures of printers and multi-function printers. This paper will provide the guiding targets for the printer manufacturer, standardize the enterprise behaviour of printer, and lead the printer product enterprise to implement the product green design, which is of great significance in promoting the transformation and upgrading of printer product, enhancing the green manufacturing level and increasing the green product supply.

1 Introduction

The printer industry is a mature industry, and the market scale is relatively stable. According to CCID Consulting, in 2020, the global printer sales volume was 87.69 million units. Except for 2019, the sales of printers in China have maintained positive growth. According to CCID consultant's prediction, from 2022 to 2025, the global printer sales will remain relatively stable, and the growth rate of printer sales in China will remain above 1%, so there is a large growth space. Carrying out green design for printers and multi-functional all-in-one machines, meets the needs of consumption upgrading, increases the supply of green products, and enables consumers to choose and use green products.

The green design of printers and multi-function printers is also called "environmental conscious design", "green design" or "design for the environment". It intends to optimize the environmental impact of printers and multi-function printers and bring the environmental factors into the product design and development activity, so as to improve the environmental performance of printers and multi-function printers within its life cycle. As shown in the study, 80% resources consumption and environmental impact are subject to the product design phase. At the design phase, it is required to fully consider the existing technical conditions, raw materials guarantee and other factors, and optimize the solution against the resources and environmental problems at each link, which may maximize the resources conservation and reduce the environmental pollution from the source [1, 2].

2 Purposes and basic principles of green design of printers and multi-function printers

The purpose of green design for printers and multi-function printers is to reduce the environmental pollution, and enhance the recyclability rate of printers and multi-function printers, so as to reduce the adverse environmental impact of printers and multi-function printers during its entire life cycle, and develop the more ecologic, economic and sustainable printers and multi-function printers system.

The basic principles for green design of printers and multi-function printers include: the requirements-oriented, advanced technology, scientific methods, environmental-friendly, economic rationality, and abidance by law.

3 Product green design process and key points

3.1 Outline

The green design of printers and all-in-one machines usually includes the following processes: a) Analyze regulations and environmental requirements of stakeholders; b) Identify and evaluate environmental factors and corresponding environmental impacts; c) Design and development; d) Review and continuous improvement.

The green design of printers and all-in-one machines should be based on the PDCA (planning, implementation, inspection and improvement) cycle process, carry out product demand analysis on the basis of full analysis of

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regulations and environmental requirements of stakeholders, identify environmental factors and corresponding environmental impacts at all stages of the product life cycle, and introduce environmental factors into the product green design process, Review and continuously improve green design through life cycle analysis and evaluation, and promote the whole supply chain and relevant parties to realize green design information sharing.

3.2 Product Demand Analysis

Under the condition of meeting the product function, the product green design should comprehensively consider the factors such as economic and technical feasibility, and the needs of laws and regulations, technical standards and customer market, so as to meet the goal of product green design.

Product demand analysis includes but is not limited to the following points: a) product green design objectives; b) Product function design; c) Requirements of laws and regulations; d) Technical standards; e) Customer and market needs.

3.3 Identification of Environmental Factors

Identifying typical environmental factors and corresponding environmental impacts is an important prerequisite for product green design. Designers can identify environmental factors according to GB/T 28179 [3]. The identification and analysis of these environmental factors can provide a basis for green design, identify, evaluate and determine important environmental factors as soon as possible, and consider introducing these factors in the process of product design and development to improve the environmental performance of products. Table 1 is an example of the environmental factor identification process of printers and all-in-one machines.

Table 1. Example of environmental factor identification process of printer and all-in-one machine products

Environmental factor	Design considerations	Product life cycle phases involved				
		Raw material acquisition	Manufacturing	Transportation and distribution	Use and maintenance	End of life disposal
Hazardous substances	Compliance and reduction of hazardous substances in raw materials (parts, coatings, etc.)	√	√		√	√
	Compliance and reduction of the use of hazardous substances in packaging materials	√		√		√
	Compliance and reduction of the use of hazardous substances in production accessories	√	√			
	Compliance and reduction of the use of hazardous substances in consumables	√			√	√
Material efficiency	Reduce the types of raw materials	√			√	√
	Reduce the consumption of raw materials	√		√		
	Green process of material processing		√			
	Improve the recycling performance of raw materials	√				√
	Reduce the environmental impact of raw material production stage	√				√
	Reduce the consumption of packaging materials	√		√		√
	Improve the recycling performance of packaging materials	√				√
	Reduce consumption of consumables	√			√	√
	Improve the recycling performance of consumables	√			√	√

Environmental factor	Design considerations	Product life cycle phases involved				
		Raw material acquisition	Manufacturing	Transportation and distribution	Use and maintenance	End of life disposal
	Reduce the consumption of production auxiliary materials	√	√			
Battery or power supply	Battery or power supply compliance	√			√	√
	Consider the disassembly of battery or power supply				√	√
	Consider the life of the battery or power supply				√	√
Energy consumption	Improve product energy efficiency				√	
	Reduce energy consumption in product production process		√			
Pollutant emission	Reduce the emission of harmful substances in the use stage of products				√	
	Reduce noise emission during product use				√	
Product longevity	Reasonably extend product longevity (modular design, parts replaceability, software upgrade)				√	
Recycling, utilization and disposal	Consider reuse, recycling and reasonable disposal					√
	Reduce environmental toxicity of final waste					√

3.4 Introducing Environmental Factors into the Process of Product Green Design

3.4.1. Functional Design.

The design and development of products shall meet the requirements of relevant functions in GB/T 9314 [4], GB/T 17540 [5], GB/T 17974 [6] and GB/T 28165 [7], including appearance and structure, function and performance, safety, power adaptability, noise, electromagnetic compatibility, environmental conditions, reliability, etc.

On the basis of meeting the functional requirements of products, green design ideas and concepts should be incorporated into the design and development process of the whole product life cycle, including conceptual design and structural design before product finalization.

3.4.2. Improve Material Efficiency.

The choice of materials will affect the environment. The method of improving material efficiency can be considered in the process of product green design according to GB/T 34144 [8].

When selecting materials, designers should consider the following factors: reduce the types of materials used; Reduce the amount of materials used, so as to reduce the weight of products; Use materials that have little impact on the environment; Use materials that are easy to recycle.

3.4.3. Restrict the Use of Hazardous Substances.

Designers need to reduce or eliminate the use of hazardous substances and products as one of the priorities in product design, and timely understand the international, regional and national management lists of prohibited hazardous substances and products, so as to ensure that the products sold in the target country are legal. Designers should minimize the use of substances that require special separation or disposal at the end of product life.

For substances requiring special treatment or disposal, appropriate information shall be provided to product users and recyclers. When hazardous substances and products are inevitably used (except those that are explicitly restricted by laws and regulations), they should be identified and marked, and the reasons for their inevitable use should be recorded in the design process.

Appropriate design methods should be adopted to reduce the possibility of using harmful substances in high-risk parts such as printer and all-in-one machine product shell, motherboard, paper feeder, print head, ribbon and external power cord.

3.4.4. Reduce Chemical Emissions.

The product is designed to minimize chemical emissions with negative environmental impact, such as volatile organic pollutants, ozone, dust, and so on.

3.4.5. Reduce Noise Emission.

The designer shall consider the technology of reducing noise emission, and the method of reducing noise emission can be adopted in accordance with GB/T 34959 [9].

3.4.6. Improve Energy Efficiency.

The design and development of the product shall meet the requirements of GB/T 21521 [10] on the energy efficiency limit value and energy efficiency grade of the printer. In order to improve the energy efficiency of products, designers should fully investigate and confirm which stage of the product life cycle will consume most of the energy, and take corresponding measures to reduce energy consumption and improve energy efficiency. The method in GB/T 34959 should be adopted to improve the energy efficiency of products.

Examples of energy-saving design methods to improve the energy efficiency of printers and multi-functional all-in-one machines are: design to improve the mechanical transmission efficiency of products and reduce the friction resistance, so as to reduce the energy consumption in the working process.

3.4.7. Consumables.

The design and disposal of consumables (or "consumables") should be guided by reduction, modularization and reuse: the function of reducing or saving the use of consumables; Convenient replacement or maintenance of consumables. The manufacturer can provide users with information about the correct use of consumables and, where appropriate, the end of life processing information of consumables.

Examples of design methods for optimizing consumables include: full consideration of compatibility with consumables (including reusable consumables) in product design. Consumables mainly include ink cartridge of inkjet printer, drum powder box of laser printer and ribbon frame and ribbon of needle printer.

3.4.8. Battery.

If the battery is used in the product, the design of the battery in the product should be considered from the aspects of battery type, control of harmful substances in the battery, battery durability, easy disassembly and recycling, and so on.

3.4.9. Reasonable Extension of Product Life.

When technically and economically feasible, the service life of the product design shall be extended as far as possible and matched with the service life of components, and it is easy to upgrade and repair. However, designers should consider the balance between using the latest efficient technology and prolonging the life of inefficient products.

Designers should consider integrating the following features: using common mechanical packaging (such as cover and chassis) or common components or product types are the same parts used by multiple models or the same parts used by the same product for multiple generations, allowing the reuse of common components; Use standardized components, which can be easily replaced or repaired; Modular design; Whenever the reuse of modules, components and products is applicable, the reused components (such as for maintenance and spare parts) should be identified.

When considering the design method of prolonging the product life, the printer and multifunctional all-in-one machine adopt the design of modularity, compatibility and upgrading, such as the updatable operating system.

3.4.10. End of Life Disposal of Products.

The design of the product shall facilitate the reuse, recovery and correct treatment at the end of the product life. The requirements for reuse, recycling, recycling, treatment and disposal of waste products shall be implemented in accordance with GB/T 23685 [11].

3.4.11. Packaging.

The selection and design of packaging materials will have an impact on the environment. When determining materials and designing packaging, designers should consider the following options: reduce the use of packaging materials through reasonable structural design and material selection, so as to reduce the weight and size of packaging when fully protecting products; Use materials that have little impact on the environment; Use recyclable materials; Use renewable/recyclable materials (considering available recycling technologies).

The minimum requirement for designers is to ensure compliance with international, regional and national regulations related to the following contents: restrictions on hazardous substances and hazardous products; Regeneration capacity, such as reuse or recycling; The appropriate identification (material content) of packaging materials shall comply with the marking requirements of GB/T 18455.

3.5 Product Life Cycle Analysis, Evaluation and Continuous Improvement

In order to confirm and improve the green design level of products, the methods of life cycle analysis and evaluation can be used to establish and implement the procedures of green design review and continuous improvement. The process of product life cycle analysis, evaluation and continuous improvement of product green design includes the following steps:

a) Product Description: determine the product boundary and goal of the design, including: model, specification, function, energy efficiency grade, life expectancy, etc.

b) Product demand analysis: requirements of interested parties (laws and regulations, standards, customers, etc.) in terms of function, resources, energy, environment, human health, and so on;

c) Product life cycle diagnosis: analyze and diagnose the whole life cycle of the benchmark product, put forward the potential and key points for environmental performance improvement, and put forward the improvement demand;

d) Preliminary evaluation of product green design scheme: conduct preliminary evaluation on the improved scheme and confirm the product green design scheme;

e) Product life cycle assessment: complete the whole life cycle assessment report of the benchmark product and the whole life cycle assessment report of the target product;

f) Product green design scheme evaluation: analyze and compare the environmental performance of the whole life cycle evaluation report of the target product and the benchmark product, and give the conclusion of the environmental performance of the target product;

g) Scheme selection: select the green design scheme of target products and benchmark products;

h) Scheme review: review the best scheme;

i) Scheme output: confirm whether the design scheme of the target product meets the product requirements. If so, carry out design implementation, effect evaluation and information sharing; If the expected product demand is not met, continue to put forward improvement suggestions, and re-evaluate the scheme after adjustment until the expected product demand is met.

4 Conclusions

The green design of printers and multi-function machines provides guidance for enterprise designers in green design when carrying out product design and development, from the basic principles of product green design, product demand analysis, environmental factor identification, design and development process, life cycle analysis and improvement, information sharing, etc., and from the selection of raw materials, production and manufacturing, packaging and transportation, use and maintenance Identify environmental factors at all stages of the life cycle, such as waste recycling, propose product ecological design requirements in terms of resources, energy and environment, improve the renewable utilization rate of products, reduce adverse environmental impacts in the entire life cycle of products, and develop more ecological, economic and sustainable product systems.

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4. GB/T 9314 General specification of serial impact dot matrix printer
5. GB/T 17540 General specification for desktop laser printers
6. GB/T 17974 General specification for desktop inkjet printers
7. GB/T 28165 General specification for thermal printer
8. GB/T 34144 Guidance on material efficiency considerations in environmentally conscious design of electrical and electronic products
9. GB/T 34959 Audio/Video, information and communication technology equipment—Enviromentally conscious design
10. GB/T 21521 Minimum allowable values of energy efficiency and energy efficiency grades for copy machines, printers and fax machines
11. GB/T 23685 General technical specifications of recovering for waste electrical and electronic equipment