ISSN 2616-7433 Vol. 5, Issue 18: 1-5, DOI: 10.25236/FSST.2023.051801

Research on Recycling Design of Clothing Textiles Based on Sustainable Development

Gao Jianping[1,*], Xu Feifei[2]

[1]*Graduate University of Mongolia, Ulaanbaatar, 16052, Mongolia*
[2]*The Hong Kong Polytechnic University, Hong Kong, 100872, China*
[*]*Corresponding author*

Abstract: *Based on the concept of sustainable development, the recycling and reuse of clothing and textiles has been paid more and more attention in modern society. With the increasing attention to environmental issues in the world, how to consider the life cycle and reuse of textiles in the design and production stage has become a major challenge for designers and manufacturers. In this context, textile designers and producers need to keep pace with the times and explore new design methods and reuse strategies. Firstly, this paper analyzes the design principles based on sustainable development and the challenges faced in recycling design, and further discusses the best practices of textiles in the stages of design, production and recycling from multiple dimensions, aiming at providing reference for textile design and production industries.*

Keywords: *Sustainable development; Clothing textiles; Recycling; Design strategy*

1. Introduction

With the acceleration of globalization, the garment and textile industry has shown unprecedented prosperity. People's pursuit of fashion and clothing is constantly upgrading, which leads to a great increase in the production and consumption of textiles. But at the same time, environmental problems become increasingly serious because of a large number of clothing waste and the use of non-renewable materials. The pollution of microplastics in the ocean, the accumulation of waste clothes on land and the consumption of a large amount of water resources in the textile production have aroused widespread concern. Therefore, exploring the sustainable recycling design of clothing and textiles is not only very important for the sustainable development of the industry itself, but also an effective way to respond to the global sustainable development goals and achieve a win-win situation between environment and economy.

2. The design principles of clothing and textile recycling based on sustainable development

2.1 Circular economy-oriented design

Circular economy is not only a simple economic model, but also a complete thinking and action system, which is intended to ensure the maximum utilization of resources and minimize waste in the whole process from design source, production, use to waste. When it comes to the design of clothing and textiles, the traditional "linear economy" thinking mode makes people act according to the mode of "extraction-manufacture-waste", which not only leads to a lot of waste of resources, but also causes great pressure on the environment. On the contrary, circular economy-oriented design encourages considering the whole life cycle of products from the source, starting with the selection of renewable and recyclable materials, and considering the disassembly and recycling of products at the time of design. In the context of sustainable fashion and waste reduction, it is imperative to adopt innovative design strategies that facilitate recycling and prolong the lifecycle of clothing. One such strategy involves the utilization of a single material in the production of garments, steering clear of blends, which significantly enhances the efficiency of the recycling process. Additionally, embracing a modular design approach ensures that when a specific part of a garment incurs damage, it can be replaced independently, thereby eliminating the need to discard the entire item. These practices collectively contribute to a more sustainable fashion industry, aligning with global efforts to minimize waste and promote responsible consumption. This circular economy-oriented design can not only maximize the use of resources, but also reduce the impact

ISSN 2616-7433 Vol. 5, Issue 18: 1-5, DOI: 10.25236/FSST.2023.051801

on the environment to a great extent, and ensure the harmonious coexistence between economic development and the natural environment.

2.2 To improve the ability of fiber regeneration

Fiber regeneration ability emphasizes the conversion of waste or used textiles into new fibers for further application in new clothing or textile products. This design principle focuses not only on simple recycling, but also on reuse and reproduction. From the early stage of design, we should consider how to maximize the regeneration and reuse after the end of the product life cycle, specifically to the material selection and design stage, which means choosing those fibers that are easy to regenerate, such as cotton, hemp, wool, etc., and avoiding the use of synthetic fibers that are difficult to decompose or regenerate [1]. When designing products, designers also need to consider how to make fibers easily separated, extracted and reused after use, without causing fiber performance degradation or generating a large amount of waste. In addition, improving fiber regeneration ability also means reducing fiber damage caused by dyeing, printing or other processing processes in the manufacturing process, and ensuring that the fiber is in the best condition during the whole production and consumption process. Ultimately, this design principle requires the continuous pursuit of maximum fiber regeneration and reuse in the whole textile production chain, so as to achieve real sustainable development.

2.3 Strengthen the cooperation mode of production chain

Strengthening the cooperation mode of production chain means close cooperation in every link from raw material procurement to production, sales and recycling. This cooperation mode not only ensures the efficient use of resources, but also helps to reduce the waste in the whole production process. Transparent supply chain is the cornerstone of strengthening the cooperation mode of production chain. Each link should be clear about its responsibilities and tasks, and keep close communication with upstream and downstream links to ensure smooth information. To achieve this goal, many enterprises adopt digital tools, such as blockchain technology, to track the life cycle of products and update supply chain information in real time. In addition, strengthening the production chain cooperation mode also encourages all participants to jointly develop and innovate. Through joint research and development, all parties can share technology, knowledge and resources, so as to achieve sustainable goals more quickly. For example, textile manufacturers and raw material suppliers can cooperate to develop more environmentally friendly production methods or recyclable materials. Strengthening the cooperation mode of production chain not only helps to improve the utilization efficiency of resources, but also helps to establish a greener and low-carbon textile production mode, thus promoting the whole textile industry to move towards real sustainable development.

2.4 Taking environmental protection as the consumption standard

Taking environmental protection as the consumption standard is not only a responsibility for the environment, but also a commitment to the future, which means that environmental factors are put first in every stage from design, production to consumption. During the design phase, it is crucial to adopt a holistic approach that prioritizes sustainability and minimizes environmental impact. This involves meticulously strategizing to reduce material waste and selecting materials that are low in carbon footprint, renewable, and biodegradable. By optimizing the design to enhance the durability and longevity of the product, we contribute to prolonging its life cycle, thereby reducing the need for frequent replacements and minimizing waste. Concurrently, it is essential to consider the end-of-life scenario for textiles, ensuring that they are designed in a manner that facilitates easy recycling and reuse. This not only aids in diverting waste from landfills but also plays a significant role in lessening the environmental burden, fostering a more sustainable and eco-friendly industry. In the production process, taking environmental protection as the consumption standard means adopting water-saving and energy-saving production technology, reducing the use of chemical substances, and ensuring that the waste water and waste gas of the factory meet the emission standards. In addition, the supply chain is reviewed to ensure that partners also follow environmental principles to achieve overall sustainability goals. Taking environmental protection as the consumption standard, we also pay attention to consumers' purchasing behavior. In order to contribute to waste reduction and promote sustainable practices, it is essential to implement educational initiatives aimed at consumers, guiding them towards making informed choices in favor of high-quality, durable, and easily recyclable products. Encouraging active participation in the circular economy is a crucial aspect of this educational endeavor, exemplified by initiatives such as old clothes recycling programs. Through these efforts, consumers become integral players in the sustainability

ISSN 2616-7433 Vol. 5, Issue 18: 1-5, DOI: 10.25236/FSST.2023.051801

movement, fostering a culture of responsibility and awareness that extends beyond individual purchases and contributes to broader waste reduction goals. Brands should also actively convey the message of green consumption, and let consumers make wise choices when purchasing through environmental protection certification and labels.

3. The challenges faced in the design of clothing and textile recycling based on sustainable development

3.1 The limitations of recycling technology

With the progress of science and technology, although recycling technology has made great progress in some aspects, there are still some limitations. Complex textile blending materials make the separation and recovery process complicated, especially when natural fibers are mixed with synthetic fibers, the recovery process of this blending material may lead to the degradation of fiber quality or the difficulty of complete separation [2]. Current recycling techniques may encounter difficulties in dealing with dyed, printed or other specially treated textiles. These processes may change the fiber structure or introduce chemicals that are difficult to remove, thus affecting the recovery process. In addition, although some technologies have been able to effectively recycle some textiles, there is still a lack of a universal and efficient recycling method for a wide range of textiles. In addition, compared with traditional treatment methods, efficient recovery technologies often need higher cost investment, which limits their popularization and application to a certain extent.

3.2 Complex fiber blending problems

When two or more fibers are blended or woven into a textile, this textile is called a blended material. Blended materials appear to integrate the characteristics of different fibers, for example, blending cotton with polyester can obtain the air permeability of cotton and the durability of polyester at the same time. However, this kind of blending not only brings many performance advantages to textiles, but also brings a series of problems to the recycling process. Difficulty in separation: When trying to recover a single fiber from blended materials, it is a great challenge to separate various fibers effectively and completely. Degradation of quality after recycling: Even if separation is successful, the recycled fibers may not be restored to their original state due to chemical or physical bonding that may occur during the blending process. Technical challenges: Existing recycling technologies may be better suited for processing single fiber materials, while blended fibers may require more advanced or different technologies. Economic considerations: Because the recycling process of blended fibers is more complicated than that of single fibers, the recycling cost may be higher. Environmental impact: Attempts to separate blended fibers may require the use of chemicals, which may lead to additional environmental burden.

3.3 Consumer recycling participation is low

Consumers play a vital role in the recycling process because they are end-users in the life cycle of textiles. However, in real life, many consumers may not fully understand the importance of textile recycling, or lack knowledge on how to properly recycle clothes and other textiles. In some areas, the lack of convenient textile recycling facilities or points makes it difficult for consumers to recycle clothes they no longer need. Unless consumers see immediate rewards or benefits, they may not actively participate in recycling. For example, lack of economic incentives, environmental education or social pressure may lead to low participation. Consumers may wonder whether the clothes they put into the recycling bin have really been properly disposed of, and this distrust may dampen their recycling enthusiasm. In some cultural and social contexts, used clothes are considered personal items, and it may be more common to discard them directly rather than recycle them. People are often reluctant to give up certain textiles because they are related to specific memories or emotions, even if they are no longer applicable. Improving consumers' participation in recycling is a multi-level and multi-directional challenge.

3.4 The contradiction between cost and economic benefits

In order to achieve environmental goals, it is usually necessary to invest more resources and funds, but this may lead to economic pressure and burden. Establishing a comprehensive textile recycling system requires a large initial financial investment, including recycling facilities, technology and human

ISSN 2616-7433 Vol. 5, Issue 18: 1-5, DOI: 10.25236/FSST.2023.051801

resources. However, these initial investments may be difficult to realize returns in the short term. Advanced technology, equipment maintenance, manpower and logistics in the process of recycling and reuse all need continuous financial support, and these operating costs may exceed the economic returns obtained from recycling activities. The market value of recycled textiles may be affected by a number of factors, such as raw material prices, labour costs and global market dynamics, and this instability may affect the economic viability of recycling activities. Although many consumers support sustainability, they may be reluctant to pay extra for more environmentally friendly products or services, further increasing the pressure on economic benefits. While the economic benefits may not be obvious in the short term, in the long run, investing in sustainable textile recycling may bring greater economic returns, such as increased market share, brand image promotion and government incentives. Traditional economic assessments may not adequately account for environmental and social external costs, such as pollution, health effects and resource depletion. If these external costs are taken into account, the economic benefits of sustainable recycling may become more obvious. To solve the contradiction between cost and economic benefit, it is necessary to integrate various strategies and methods, and take into account the triple goals of environment, society and economy at the same time.

4. The design strategy of clothing textile recycling based on sustainable development

4.1 Investment in technology research and development and innovation

In the process of realizing the sustainable recycling of textiles, the progress of fiber-grade separation technology makes it possible to effectively identify and separate mixed fibers, which opens a new door for textile recycling. Chemical dissolution methods are more environmentally friendly. They use chemicals with low toxicity and low environmental impact to transform textile waste, thus better ensuring environmental safety. Machine learning and artificial intelligence technology came into being at this time, which provided the function of image recognition for textile classification and greatly improved the speed and accuracy of classification [3]. At the same time, the application of biotechnology has brought new life to textile materials which are difficult to recycle, and the degradation of microorganisms and enzymes has enabled fibers to regenerate. The potential of 3D printing technology in textile reuse is gradually emerging, which injects new vitality into recycled fibers. Combined with automation and robot technology, the efficiency of the whole textile recycling process has been significantly improved. Finally, through intelligent supply chain management, every link of textiles is closely connected, thus ensuring seamless connection and efficient operation of the whole recycling process.

4.2 Designing textile materials that are easy to separate

Facing the problem of textile recycling, choosing suitable fibers and design skills become the key. The first step is to use a single fiber manufacturing, such as PET, cotton or acrylic fiber and other single materials to make products, so as to avoid complex blending between fibers [4]. In the structural design of textiles, mechanical stitching rather than chemical bonding should be considered to ensure easy separation during the recycling stage. Bio-based fibers, such as polylactic acid (PLA) or protein-based fibers, can also be included in the design, and they have good biodegradability under specific conditions. At the same time, in order to ensure effective recycling, textile labels should clearly mark fiber types and contents, supplemented by two-dimensional code or radio frequency identification (RFID) technology, which is convenient for later automatic sorting. For textile decorations and accessories, such as zippers and buttons, it is recommended to use the same material as the main material, or to design a structure that is easy to disassemble. In addition, in the dyeing and printing process, the selection of biodegradable or non-toxic dyes and inks can simplify the treatment process after recycling.

4.3 To improve consumer education and publicity

Conduct regular consumer education activities, such as seminars, workshops or online courses, specifically on the sustainability and recycling of textiles. In addition, standardized information materials such as brochures, posters or brochures detailing the importance and processes of textile recycling are developed to ensure accurate communication. Partner participation is also key, working with textile brands, retailers and designers to promote recycling and reuse messages and provide more attractive and authoritative promotional materials. To effectively promote textile recycling and sustainability, it is imperative to leverage digital technology to create an accessible and user-friendly platform for

ISSN 2616-7433 Vol. 5, Issue 18: 1-5, DOI: 10.25236/FSST.2023.051801

consumers. Utilizing mobile applications or websites, we can provide real-time updates and interactive features that inform users about the locations of recycling points, the specific requirements for recycled materials, and other pertinent information. Additionally, the installation of interactive exhibitions and information screens in strategic locations such as public spaces, shopping centers, and schools can significantly enhance the visibility and reach of our educational efforts. To foster active participation, innovative initiatives such as textile recycling competitions can be introduced, with rewards and recognition given to consumers or groups who demonstrate exceptional commitment to recycling. Furthermore, establishing partnerships with media outlets can amplify our message, leveraging their extensive reach and influence to ingrain the principles of textile recycling and sustainability in the public consciousness. Through these comprehensive strategies, we aim to cultivate a culture of environmental responsibility and encourage widespread adoption of sustainable practices.

4.4 Seeking a balance between economy and environmental protection

For the textile industry, it is particularly critical to seek a balance between economy and environmental protection, because it will affect the whole industrial chain, from raw material procurement, production process to final product sales [5]. Raw material strategy: Purchase fibers and dyes with traceable sources and environmental protection certification. Although the initial cost is high, in the long run, it can reduce the extra cost and potential legal risks caused by environmental pollution. Production process optimization: adopt closed-loop production system to reduce water and energy consumption. Through efficient production process, unnecessary waste is reduced, thus reducing the manufacturing cost per unit product. Implementing a thoughtful pricing strategy is crucial for promoting environmentally friendly products. Products should be priced reasonably, taking into account their eco-friendly attributes and life cycle costs, while also communicating the long-term value they offer to consumers, such as their durability and recyclability. In terms of brand and market cooperation, it is beneficial to partner with established green brands or organizations. This collaborative approach allows for the sharing of resources and knowledge, subsequently reducing the challenges and risks associated with transitioning towards more sustainable practices. Additionally, there is a significant opportunity to expand into the recycled material market, particularly in the realm of recycled fibers. Utilizing waste textiles as raw materials not only diminishes the reliance on new materials but also opens up new revenue streams for the company. Furthermore, exploring cross-industry collaborations, such as partnerships with the used household appliances and automotive industries, can lead to shared recycling channels and treatment facilities. This approach promotes resource sharing and cost distribution, ultimately contributing to a more sustainable and economically viable business model. In addition, the introduction of circular economy business models, such as clothing leasing and recycled fiber sales, will create a new profit model for enterprises and respond to the green and sustainable concept.

5. Conclusion

In a word, the design of clothing and textile recycling based on sustainable development has far-reaching significance for realizing the dual goals of environmental protection and economic growth. Under the background of current environmental crisis and resource shortage, the promotion and practice of this design concept is particularly important. Therefore, designers, manufacturers and stakeholders must deeply understand the connotation and application of this concept, and actively seek solutions that combine with the actual needs in the process of production, consumption and recycling. Only in this way can we ensure that the practice of textile recycling design can really contribute to the goal of sustainable development and lead the textile industry to a greener and more environmentally friendly future.

References

[1] Song Chenghao, Wang Qifan.A nalysis on the recycling design of clothing and textiles under sustainable development [J]. Western Leather, 2023, 45 (15): 124-126.
[2] Yang Xing, Li Qingzhou, Wu Min, et al. Green recycling in EU textile industry chain and key issues of waste textile treatment [J]. Journal of Textile Science, 2022, 43 (1): 106-112.
[3] Li Shuai. Research progress on the application of 3D printing in smart textiles [J]. Silk, 2022, 59 (9): 45-54.
[4] Wang Fubang, Gong Jixian, Ren Yanfei, etal. Research progress of tea pigment preparation and biological dyeing of natural fibers [J]. Knitting Industry, 2022 (8): 72-77.
[5] Wang Jing, Du Jianxia. Comparative analysis of waste textile recycling methods under the concept of sustainable development [J]. Textile Science and Technology Progress, 2021 (7): 11-14, 39.