Brief Analysis on Closed-loop Ecosystem of Textile and Clothing Recycling

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Abstract. This paper introduces the integrated recovery and utilization of waste textile, and discusses the closed-loop ecosystem for the textile and clothing recycling, and then analyses its recovery, product development, transportation, packaging on such basis, which provides references and suggestions for the benign development of the integrated recovery and utilization industry of the waste textile in China.

1. Social Reserves and Overall Overview of Waste and Old Textile in China
China is the world's largest textile fiber producer, with the processing volume of textile fiber of 53 million tons in 2015. With the accelerated development of industry, various types of waste and old-fashioned textile and clothing have gained rapid growth, resulting in a great deal of clothing garbage. To this end, China attaches great importance to the recycling of waste and old-fashioned textile, introduced a series of policy documents in succession, like *Circular Economy Promotion Law of the People's Republic of China*, *Opinions on Accelerating Ecological Civilization Construction*, *Catalog of Integrated Resource Utilization Product and Labor Service Value-added Tax Preference*, incorporates relevant contents into the "Twelfth Five-Year Plan" of China's textile Industry, and establishes the "Double-hundred Engine" to subsidize the project funds, etc. [1]

As revealed in *Zero Abandon of Used Clothes - Research Report on Waste Textile Recovery and Recycling in China in 2014/2015*, there were 20.073 million tons of waste textile in 2013, of which the synthetic fiber product was 13.777 million tons, accounting for 69% of the total stock; the cotton product was 5.62 million tons, accounting for 28% of the waste textile; other natural fiber product was 676,000 tons, accounting for 3% of the same.
Currently, the recycled waste textile was about 3 million t/a in China, with the multipurpose utilization rate of 15%. From the international markets, the European and American countries have developed more perfect recycling system, which is to sell as second-hand clothes as its main utilization way, with the total utilization rate of more than 50%. About 60% of the waste textile in France is exported to Africa and Eastern Europe; about 60% of waste clothing recovered by German SOEX Company is sold out as second-hand clothes; some states in America incorporate the waste clothing recovery into the municipal recovery system, and some brand enterprises, like Nike, Adidas and others, would set used clothes recycling bins in the malls, and cooperate with charity institutions. Currently, there are about more than 300 used clothes recycling enterprises across the entire America.

By contrast, the waste textile recycling in China lags far behind. The waste clothing accounts for 4% of the total garbage in China each year, with a significant increasing trend, while the recycling rate of the waste clothing is less than 1%. A large number of used clothes are sent to the landfill or the combustion field finally, resulting in a waste of resources and significant increase in the burden on the environment, and the raw material of textile fibers is also in short supply. The used clothing is a renewable resource, and can be recycled and reutilizes through collection, sorting and cleaning, which is of significant importance to the reduction of environmental contamination, the promotion of circulation economy development and the facilitation of energy saving and emission reduction.

2. Construction of Closed-loop Ecosystem of Textile and Clothing Recycling

Due to the prevalence of fast fashion, the service cycle of clothing becomes shorter and shorter, and the upgrading and replacement speeds up sharply, resulting in a great deal of clothing garbage directly. However, from the perspective of global clothing procurement innovation to the development of textile recycling channel, H&M Company is an advocator for the concept of human sustainable development and a role model in realizing the closed-loop mode of clothing. [2]

2.1. Composition of H&M's Closed-loop Mode

The traditional linear economy is constituted by forward logistics, which adopts a single-direction structure of "Resource Product - Wastes". The closed-loop mode under circular economy adds reverse logistics process of "Waste-Resource", thus forming a recyclable closed-loop supply chain in the industry.
The figure above analyzes the compositions of H&M's ideal closed-loop mode, which starts from the selection of raw materials, leads the customer to participate in the used clothes recycling activities through green design, cleaner production, green package and transportation and advocacy of green consumption, making the recycled clothing into reutilized raw materials, and then put them into production of products as recyclable materials, so repeat in this way. [3]

2.2. Selection of Raw Materials and Fabrics
H&M advocates using organic fabrics and recycled material as well as sustainable innovative fabrics and other sustainable fabrics for production. The natural raw material used the most by H&M is cotton (including the internationally certified organic cotton, recycled cotton and high-quality cotton). The natural raw material refers to the fibrous materials without applying or generating polluting substances during its growth and production, or does not produce any irritation and interference to the human body when in use. H&M is expected to use sustainable cotton by 100% by 2020. The recycled cotton, namely the regenerated cotton, is made by recycled waste cotton fabrics, which reduces the utilization rate of the original resources, and relieves the stress on depletion of resources.

In addition to the natural fabrics of cotton, the chemical fiber is also one the most commonly used fabrics by H&M. By now, H&M is one of the companies that use the most recyclable polyester fiber. The polyester fiber is one type of chemical fibers, and the long-chain high-molecular polymer containing ester group is featured with short life cycle and easy-to-recycle after use. Although some polyester fibers are derived from petrochemical materials, it is of a certain environmental protection nature as a recyclable material; furthermore, the polyester fiber recycled from clothes has lower damages to the environment than the native polyester fiber. [4] Compared the recycled polyester fiber with the native one, it not only saves the raw materials, but also can reduce the energy consumption by 30%. H&M, by using recyclable polyester fiber, has completed the closed cycle for the life cycle of clothing.

2.3. Product Development and Sustainable Design
H&M observes the principle of appropriate design in product development, in product development, with its style dominated by fashionable and popular basic models, pursues the durability of clothing, with the clothes serving multi-purpose and used in several seasons by improving the integrated utilization rate of clothes, promotes the reutilization, and combines the sustainable concept with the product development. [5]
Each year, H&M will launch a series of "H&M Conscious Exclusive", and show the sustainable design through product to the consumers directly. The product is made of silk linen, recycled flax, tencel, blending and a variety of innovative sustainable fabrics, including the passementerie made by recycled glass as well as the accessories made by recycled jean fabrics, etc. Such series of products is the major achievement of H&M's sustainable concept, and the closed-loop recycled materials are applied in design specifically.

2.4. Cleaner Production and Green Transportation and Packaging
The cleaner production is to reduce the environmental pollution at the source, improve the source utilization efficiency, avoid or reduce the pollutants and wastes resulting from the production and relieve the damages to environment and human health by improvement of technologies, management and integrated utilization, use of clean energy, adoption of advanced equipment, etc.[6] H&M establishes a self-evaluation system with reference to the international monitoring standards, gathers the data on wastewater, air emissions and others involved in the production of manufacturers, and monitors the implementation of the manufacturers in sustainable concept.

H&M cooperates with transportation companies to reduce the pollution generated during the transportation, and analyzes the data on pollutant emission through environmental performance index assessment system, so as to make it conform to international environmental standards. H&M adopts the recyclable plastic and recycled paper as packaging materials for their products, and recycles such packaging materials as well.

2.5. Recycling and Reusing of Used Clothing
H&M launches a used clothing recycling program, and encourages the consumers to recycle the waste and old-fashioned clothing. H&M sets up used clothing recycling points at designated stores, and offers a discount card to the consumers donating clothes to encourage such donations. [7] According to the statistics, since H&M launched such used clothing recycling program in 2013, it has collected 220,009 tons of clothes in the stores, and the textile fabric of these used clothes can be used to make about 100 million T-shirts. H&M will classify and process such recycled used clothes, and those wearable will be donated to the charity institutions after disinfection, and those cannot be worn any more will be classified based on its fabrics, which can be divided into recyclable and non-recyclable. The recyclable used clothes will be made into textile, and those non-recyclable will be processed by proper methods, reducing the secondary pollution to environment.

3. Conclusions
It is an inexorable trend to develop and apply the technology of harmless, minimization and resourceful treatment of solid wastes for the sustainable development in the new century. The innovative closed-loop textile clothing recycling ecosystem is a major breakthrough in textiles recycling closed-loop field.[8] The system is designed to study at least one of the existing technologies, recycle and process the clothes made of blended fabrics for new fiber and yarn. The project has successfully developed a kind of hydrothermal (chemical) process and biological process, which completely separates and recycles the cotton and polyester fiber. The recycled polyester fibers can be reused directly, without any quality loss. Such technology will be of benefit to the sustainable development of environment, human beings and communities.

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