The circular economy: a new paradigm for the textile and clothing industries

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Abstract. The Circular Economy (CE) is an approach that requires a paradigm shift from waste management and recycling to a completely new circular system in the textiles value chain. It is supposed to be linked with both the economic growth and harmonization with ecological systems. The paper investigates the limits of the existing linear model of textiles production and consumption. The supply chain in the CE model as an alternative to the linear model is presented. The formation of "loops" in the CE and their role for recovering the products' value is analyzed. The environmental issues that arise with the new paradigm shift are also discussed. The difference between recycling and CE model is examined.

1 Introduction

The "take-make-use-dispose" model [1] considers nature as an endless source of raw materials, which can be used for the benefits of consumers and corporations without restraints. However, humanity is living in times of growing environmental problems related to climate change, increasing levels of pollution, scarcity of resources, loss of species [2].

The production of textiles and clothing is considered to be among the most polluting industries in the world. From its placement on an industrial basis until today, the textile industry follows a linear model of production (Fig. 1). The raw materials are converted into fibres that are used for spinning of yarns. Weaving, knitting and non-woven technologies are then applied to produce textiles. Apparel, home textiles, protective clothing and other items are finally manufactured as end products. After their use, the items are left as waste and replaced by new ones.

All production steps in Fig. 1 require a high consumption of energy, water, and harmful chemicals while generating solid wastes and noxious gasses during production, transportation, and use [3]. The production of synthetic fibres is based on the use of non-renewable resources. The production of cotton requires chemicals, water, and land [4], which could be used in other situation for food production.

The wet processes (wool washing, the wet spinning of flax fibres, sizing, dyeing, printing) require freshwater and much energy for drying [5]. At the same time, the wet processes produce wastewaters, rich in chemicals and salt [6]. The transportation of textile goods from low-income to high-income countries is accompanied by huge fuel consumption. In packaging, a lot of non-biodegradable materials are used [3].

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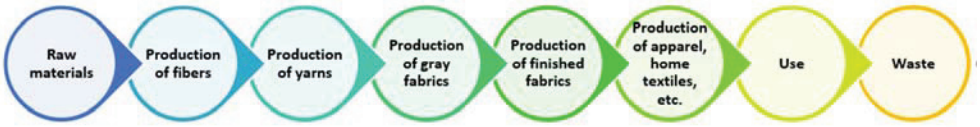

Fig. 1. The linear model for textiles and clothing production

Even the use of textile and clothing items is harmful to nature: Browne et al. [7] have found that the single washing of a clothing item could produce 1900 microfibres. They estimated that the washing of 6 kg of synthetic garments in a domestic washing machine leads to the release of up to 700 000 plastic microfibres [8]. Microplastics can be ingested by a wide range of species both in marine [9] and freshwater environments [10], thus affecting their growth, reproduction and survival. The textile industry is on the third place for the production of plastic waste in the world (15%), after the packaging (36%) and construction industries (16%) [11].

A paradigm shift is needed to a completely new circular system in the textiles value chain. The "take-make-use-dispose" model has to be replaced by the "take-make-use-return" (or "take-make-return" [12]) model, which is a substantial part of the Circular Economy (CE).

The paper investigates the limits of the existing linear model of textiles production and consumption. The supply chain in the CE model as an alternative to the linear model is presented. The formation of "loops" in the CE model and their role for recovering the value of the products are analyzed. The environmental issues that arise with the new paradigm shift are also discussed. The difference between recycling and CE model is examined.

2 Circular economy vs. Linear model

The CE is defined in [12] as: "An industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models".

The CE model aims to assure the sustainable management of all resources from the raw materials to land, air, soil, water and energy. The "Circular Economy Strategy" [14] of the European Commission defines the waste and recycling goals, the necessary improvement of the waste legislation and focuses on specific targets, e.g. banning the landfill of recyclable plastics by 2025.

The origins of the CE can be found in the general systems theory [15], environmental economics [16], and industrial ecology [17]. Its roots can be found in other models, e.g. the regenerative design [18], biomimicry [19], cradle-to-cradle design [20], blue economy [21], and performance economy [22].

In the specific case of the textile and clothing industries, the CE model tries to preserve the value of the clothing and textile items, minimizing the consumption of raw materials, energy and natural resources (water, land, etc.). The linear model (Fig. 2) leads to adding value to the product at each step of the production chain: from the production of materials, through the production of textiles and the assembly of items, to the retail. The textile and clothing items reach the user when their value is maximal (due to design, technology, brand, etc.). However, in the process of the items using, the value is destroyed (sometimes

rapidly) because of the exploitation and maintenance. The life cycle of the products ends with the end of their use.

In the CE model (Fig. 3) the idea is to follow the "waste is food" principle [23].

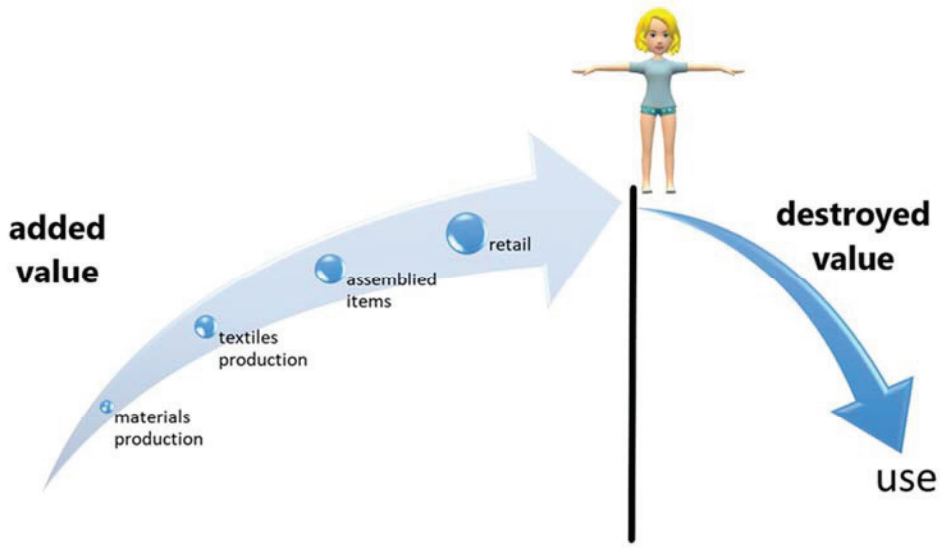

Fig. 2. The supply chain in the linear model for textiles and clothing production

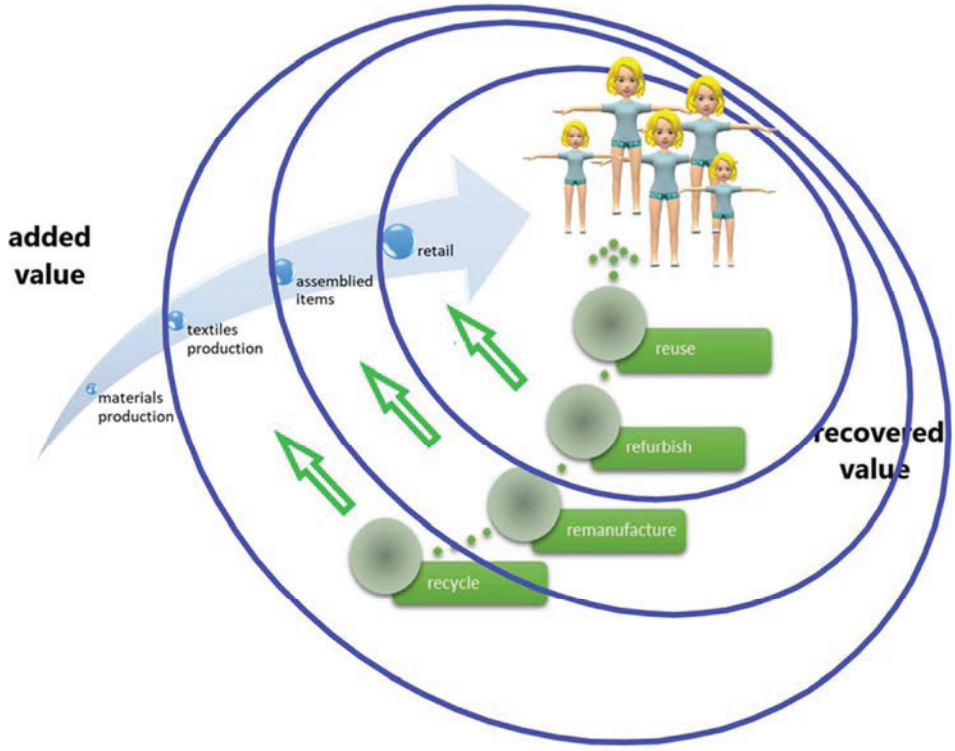

Fig. 3. The supply chain in the CE model for textiles and clothing production

The supply chain is the same, as in Fig. 2, but differences start after reaching the user on the top of the chain. The distinctions affect the phase of the item's use, which increases, due to reuse and/or redistribution of the textile and clothing items. Thus, a single item could be used by more people than in the linear model. An essential feature of the product's use is maintenance, which retains the value of the item.

The CE model also affects the phase of the value degradation (Fig. 3), which is entirely different from Fig. 2 and leads to the recovering of the item's value. The phase of use collaborates with the phase of adding value, so "loops" are formed between them. As closer to the user the loop is, as lesser energy and resources require [13]. Thus, through refurbish, the items could be easily subject to retail again, or through remanufacture could be used in the assembly step to produce new items. Recycling is a source to produce new textile items. In any case, the preservation of the added value of the product is assured much more and for a longer time than in the linear model [24].

3 The organizational change

The shift from the linear model to the CE model requires organizational changes in the production chain. The companies, involved in the CE value chain are more interconnected than the companies, which are involved in the well-known linear economy [25, 26]. The reason is the greater complexity of the CE model.

The formation of a "loop", which closes the cycle (Fig. 3) creates interdependences of different types. In one case, distinct competencies or complementary assets should be jointly applied, for example, for the refurbishing of clothing items. In another case, joint management of the materials is required (pooled interdependence) [27]. If a company uses the output stream of a second firm in the following stage of the cycle, interdependence is also created (sequential interdependence) [28]. If a company provides a particular product (material, resource, know-how) for other companies in the cycle, this also creates interdependency (reciprocal interdependency) [29]. The formation of loops leads to the involvement of a greater number of players in the production chain, with increased complexity in communication, decision making and information processing and storage [30].

4 The effect on the production chain

An important feature of the CE model is that it focuses on the consumption of fewer materials in order to be as environmentally efficient as possible. The main concern of the CE model is the natural resources, renewable (land, wood, renewable energy) and irreversible (petroleum products, non-renewable energy sources), as well as their purity (soil, water, air), which affects both humans and biota. At the same time, it focuses on increasing the period of use of products and their raw materials. Therefore, the use of toxic materials or toxic chemicals and compounds for the production of textiles and apparel must be avoided. The goal is each material, used in the production chain, to be involved in loops as a potent and healthy substance to create new cycles.

From this point of view, textiles and apparel products, which are traditionally treated as waste streams after the end of their life (the end of use), in the CE model become an input to other production processes [31]. The CE model makes it possible to use the end-products again and again as an input for new industrial cycles. At the same time, both the economic growth and the reduction in the number of raw materials needed are combined, leading to regenerative abundance. In other words, the CE model stipulates a strategy that brings together ecology and economics [13].

5 Circular economy vs. Recycling

Many think that CE is just the new face of recycling. However, the diagram in Fig. 3 shows that recycling is the worst possible option for recovering the value of the textile and clothing products: being furthest from the use stage, it requires most energy than all other options (reuse, refurbish, etc.).

Besides, to focus on recycling is not the right decision. The highest value for wasted textiles and garments is obtained through closed-loop recycling [32] that brings the product into the same format as it originally was. However, textiles often are made of mixed materials, which could hardly be separated (if possible, at all) into their original form. The results are that the textile waste is recycled in a lower-class product: e.g. shirts from expensive long-staple cotton fibres turned into wadding for bus seats.

There are several obstacles, which make the recycling process expensive and hard to be done. The first one is related to pure technical barriers: e.g. the separation of cotton fibres from a mix with polyester is still not possible. The recycled items could not enter the market again, having the same value and performance as the original materials. It results in a waste of energy, time and money, which leads to degradation of the product's value.

The second obstacle is related to the infrastructure: there is an absence of capacity for waste collection and its reprocessing on industrial level [33]. The sorting systems are also not fully optimized.

The third obstacle is related to the investments: the private sector considers the investment in recycling and new technologies as a risk [32]. One of the reasons is the lack of evidence of the return of the assets.

The CE model proposes a meaningful solution out of the recycling space. Indeed, the investments in recycling technologies and companies support the linear model and delay the shift to the CE model.

In the CE model products are made to last several lifecycles so that the resources do not end their life as recyclables. The idea is to close the loop as closer to the user as possible (Fig. 3). Thus maintenance, repair, reuse, redistribution, refurbishment becomes such vital steps in products' lifespan. The ideal situation is the product never to end up in the recycling loop, where the energy demand is highest, and the obtained quality of the recycled product is lowest.

6 Conclusions

The CE model has several advantages over the linear economy model. The approaching transition to the CE model would lead to benefits for the economy, society and nature, as the nowadays consumers attitude is dangerous for all of them. The fast-changing fashion trends, which provoke short life of apparel items, the expanding population of the Earth, the pressure for lower prices of textiles and clothing, the increased textile waste worldwide have a negative impact and shows the end of life of the linear model.

The transition towards a circular economy requires many efforts from the companies, which should start with the proper design and development of the textile and clothing items that will assure their ease of use, reuse, maintenance and refurbishing. Critical is the information, sent to society, as the old-shaped model of recycling should be replaced in the mind of consumers with the messages of the CE.

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