
Designing Work wear for Textile Industry Workers Using Pre-Consumer Textile Waste

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Abstract

The demand for stylish clothing and surge in consumers' interest towards fast fashion contributed to increased use of natural and synthetic fibers. Traditional natural fibers have been in use since ancient days. Man-made fibers are used to increase production in a limited time and with technological advancement its use has surged. This comes as an alternative to natural fibers at a cheaper cost. However, the downside of quick fashion is fewer wears per item of clothing, which leads to hazardous environmental pollution and landfills. This led to recycling of fibers. Recycling is done from pre-consumer and also from post-consumer wastes. This paper aims to use pre-consumer textile waste for developing uniforms for textile industry workers.

Keywords: *Pre-consumer waste, textile waste, workwear, recycling, sustainability, ergonomics.*

1. INTRODUCTION

The three basic needs of mankind are food, shelter, and clothing. From the primitive age, mankind has been experimenting with a lot of naturally available materials to cover and protect their bodies from extreme climates and insects. They slowly developed clothing and decorated themselves according to the ranks they possessed among their peer group. Naturally available materials like cotton, leather and other materials were spun and tanned and they also used animal bones and nerves as needles and threads.

Mankind started exploring the naturally available materials to use for their clothing and also they started finding materials for dyeing of the yarns and fabrics they created. Years later innovators came up with new inventions of synthetic fabrics to overcome the drawbacks which are inherent in the natural fibers. The fully first man-made fiber was introduced in late 1930s. To cope with the demand for clothing and unique properties of man-made fibers, its use has been increased. Man-made fibers are artificial fibers produced in factories unlike natural fibers produced in lands that consume specific amounts of water, soil quality, and time for harvest. Due to the high demand for man-made fibers, its price compared to natural fibers dropped. [1]

The usage of man-made fibers have surged and also natural fibers have to cope up with the fast fashion where the number of wears per garment is less and after use, they are thrown away which leads to more landfill. Natural fibers decompose after a certain number of years if it is fully eco-friendly while even natural fibers with chemical finishes and man-made fibers take years to decompose which affects the soil, and pollutes the water bodies, air, and the living organisms in it.[2]

In order to give long life to the created fiber or yarn, recycling process have been introduced where the fibers of the fabrics will be separated and then after undergoing certain processes, it will be again used

as yarns and fabrics will be made from those yarns. The fabric wastes are classified into two types of wastes. One is the pre-consumer and the other one is the post-consumer waste. Pre-consumer wastes are nothing but the clean waste which are collected from different stages of production from yarn to fabric. It is the waste generated before its consumption by consumers. The wastes which is left after the use of consumers are identified as Post-consumer wastes. [3].

Fabrics can be produced through mechanical and chemical processes of recycling pre-consumer waste. Also, as the recycled yarns lacks strength compared to virgin yarns, these can be used for related products. Here, workwear can be designed using pre-consumer cotton waste with the blend of polyester to give strength to the fabric and the garment has to be designed ergonomically

1.1 Linear vs Circular Economy:

There are two methods of using the fabrics:

1. Linear method
2. Circular Method

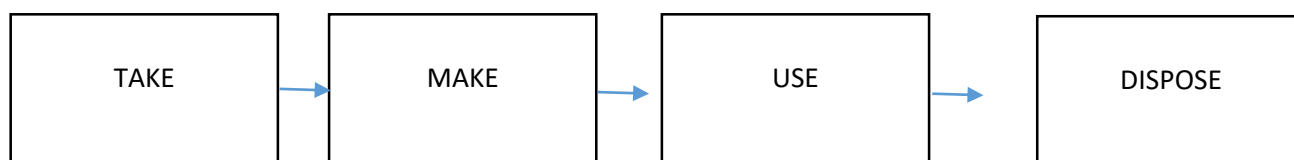


Fig:1 Linear Economy Model

Businesses are to be redesigned in order to reduce the consumption of resources. Linear economy model is about taking raw materials, making products by the manufacturers, using and disposing them by the consumers. Whereas in the circular economy model, once the raw materials are used to make products, consumed by the consumers and waste generated, those can be either reused for consumption or recycle, repair or remanufactured and then again it can be consumed. [4].

1.2 Recycling of yarns:

Recycling of fibers can be achieved by separating the fibers of the waste fabric and yarns with the help of mechanical shredding machine where the fabrics are torn by the machine into smaller pieces and eventually into fibers. Such fibers would have short lengths and when converted into fabrics again will have some small lumps. To reduce this, the recycled fibers are blended with virgin fibers which produce coarser yarns using rotor spinning. [10]

Rotor spinning produces only coarser yarns up to 20Ne commercially. Yarns made from rotor spinning have many disoriented fibers that are wrapped around the yarns that leads to construction of yarns which makes a hard fabric. This is a limitation in using rotor yarns. While ring spinning is widely used spinning system as it produces low-twisted yarns which makes it absorbent. Any natural fiber such as cotton, wool and synthetic and their blends can be spun using this.

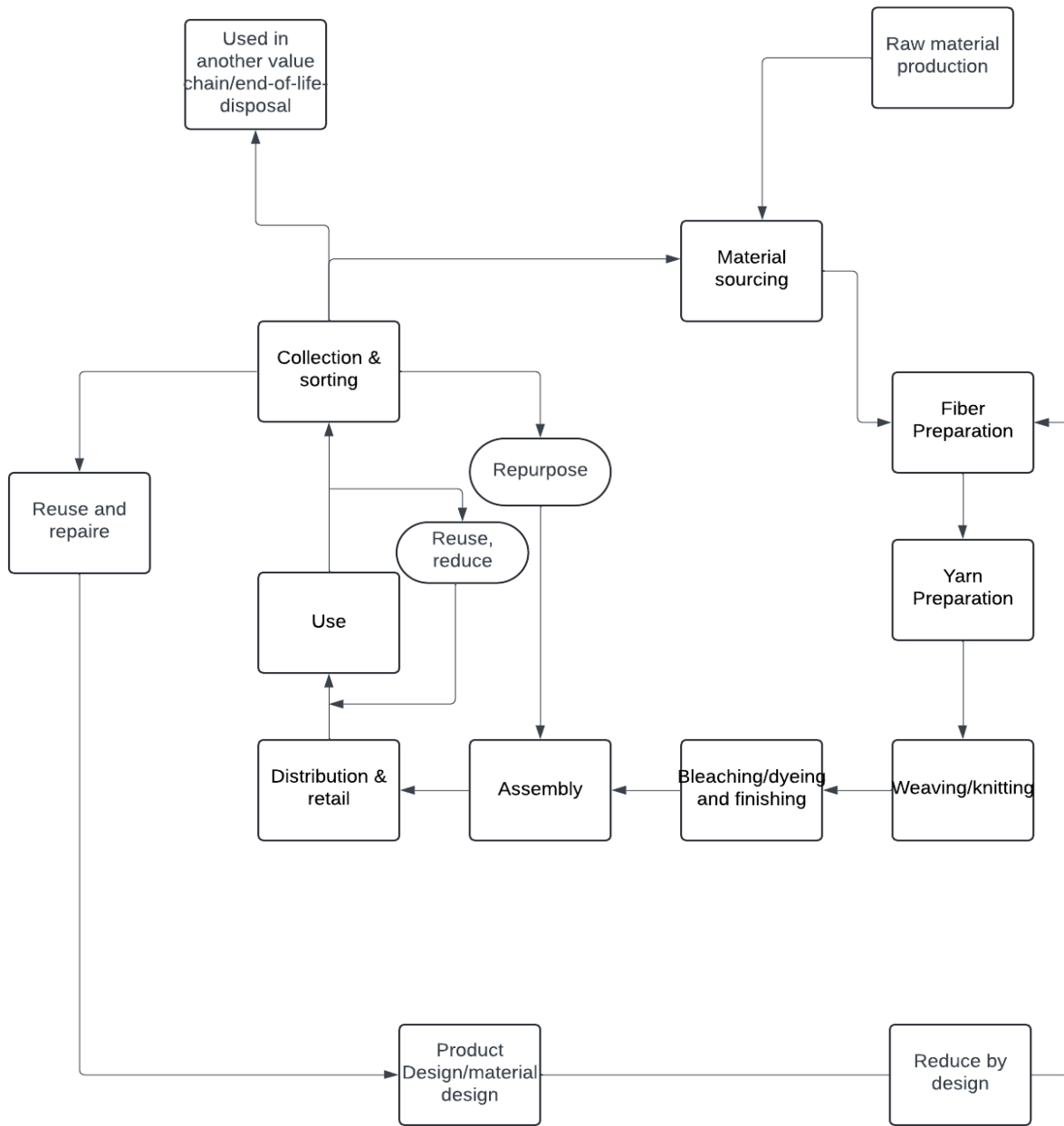


Fig:2 Circular Economy Model

1.3 Ergonomics in clothing:

The definition of ergonomics is the scientific study of human productivity in the workplace. It examines five factors such as safety, comfort, usability, performance and aesthetics to improve the design or fit of the garment. And the scientific study of the measurements and proportions of the human body which is called anthropometry must also be done.[5]

Sl.No	Tools	Sl.No	Measurements	Sl.No	Measurements
1	Stadiometers	1	Weight	12	Crotch
2	Anthropometers	2	Standing	13	Buttock extension
3	Bicondylar Calipers	3	Height from eye	14	Abnominal extension
4	Skinfold Calipers	4	Stature	15	Gluteal furrow
5	Scales	5	Cervical	16	Stylian
6	Posture Evaluation Kit	6	Mid shoulder	17	Trochanter
7	Palpation Meter	7	Supra Sternum	18	Knuckle
9	3D Body Scanner	8	Acromion	19	Dactylion
		9	Sub Sternum	20	Mid patella
		10	Elbow	21	Lateral Malleolus
		11	Waist		

2.Review of Literature:

Dissanayake et al.[6] discusses about the emerging trends in the applications of the fabric recycling and its obstacles. The mostly studied fabrics are pure cotton (50%), cotton and polyester blend (29%). The most studied method is mechanical recycling (43%).

Sandin et al.[7] says that in the process of production of garments, textile wastes are generated. Those are classified into two types of wastes. One is soft wastes, those which are the residue of blow room, carding, and combing section in a spinning mill. Similarly, hard waste can be segregated as pre-consumer and post-consumer wastes. Ajila [8] states that wastes derived prior to consumer consumption are called pre-consumer wastes. Those are often clean waste, and those can either be fabric or yarn that needs to be recycled in order to be used in new products. On the other hand, most clothing that is thrown away after usage is classified as post-consumer waste. Additionally, those can be used once more in the manufacturing process to create other or comparable products through recycling. Swetha et al.[9]Nature and volume of pre-consumer textile waste were collected from different sources and fashion products were developed. Survey was conducted to understand about the volume of pre-consumer waste from textile industry. Consumer willingness survey was studied for the marketability.

Upama et al. [10] developed a particular boy's t-shirt style production was studied to come up with the cutting waste of a factory for bringing in circular fashion. It has been found that around 2238 pieces of circular design products can be possibly manufactured from 218.6 kg of extra fabric, 212.13 kg of reusable cutting waste and 210 rejected cut panels are reusable. They directly used the pre-consumer waste from the cutting sections and it proved to be more efficient. Yeasin [11] states that recycling cotton fibers possess less quality than virgin cotton. Therefore, it has been blended in rotor spinning and produced coarser yarns of 10-20 Ne. It's stiff and poor moisture absorbent. Soft and combatively more moisture absorbency in yarn for knits can be produced through ring spinning using pre-consumer and post-consumer waste for soft twisted 30 Ne. decrease in yarn properties are more in post-consumer yarn than pre-consumer yarns. Blend yarns with 25% of pre-consumer recycled fibers are compatible for

producing knit and wovens and 10% recycled yarns from post-consumer waste are suitable for knit fabrics with better yarn strength.

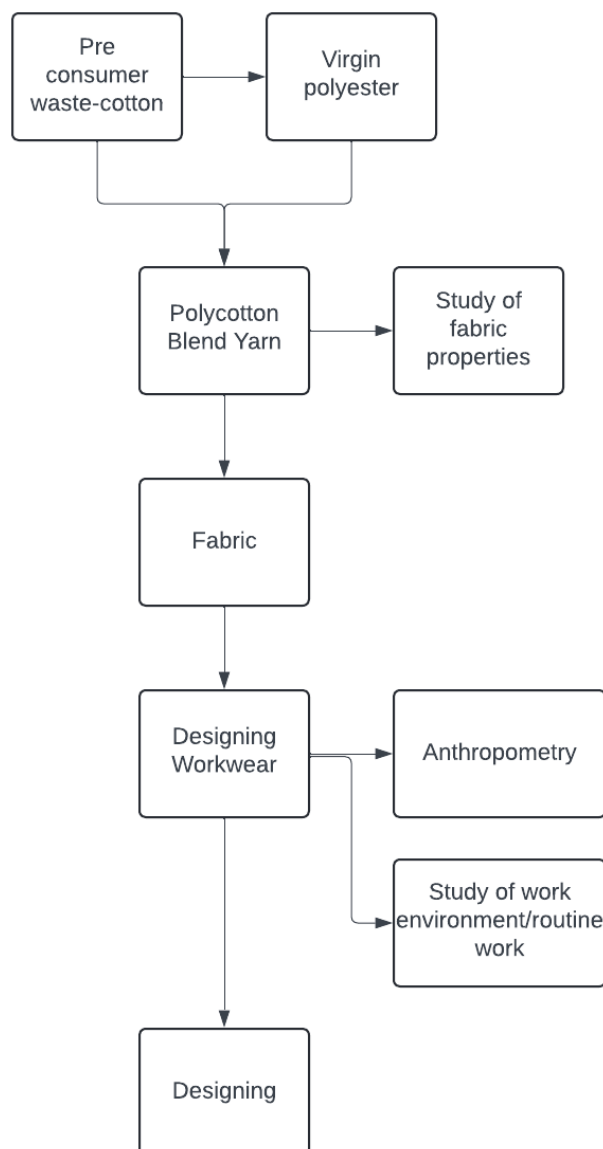
Ananya et al.[12] discusses about two types of high count yarns namely, MRY1 and MRY2 which were produced with the objective of producing high count yarns using manual spinning method. This was to produce repurposed yarns using textile pre-consumer waste. NYY1 is 0.44Ne and MRY2 is 0.98 Ne count respectively. These can be used for the production of apparels to home furnishings. They have better tensile strength and wash fastness properties. Tenacity and CV% elongation at break for both yarns are comparatively poor.

Erica et al. [13] states that biophysical, anthropometrics and social characteristics must be taken into account while designing for action/task-oriented clothing which would provide them comfort, satisfaction and subjective needs of the person wearing it. Structural and physical qualities influence the positiveness towards the product. Christian et al.[14] experimented and recorded the postures and movements involved during the work. Here, body postures are recorded using the prototype of smart work clothes with 15 inertial sensors. 111,275 postures were recorded. Raphael et al. [15] discusses about the health conditions of factory workers who are exposed to long hours of sitting postures, poor workspace conditions, routine tasks that affects their health. They say that they suffer various health issues including musculoskeletal disorders or pains. Marcia et al. [16] concludes that Cotton and polyester blend are most often used in the uniforms. Cellulosic fibers absorb the body sweat and transfers to the outer surface of the garment. Hence, the body can maintain temperature. Flammability is an issue in uniforms. LOT (Limiting Oxygen Index) in professional uniform was from 17.4% to 30%.

3.Methodology:

There were some challenges in the making of finer yarns for producing fabrics from the recycled yarns. So, it could be done through ring spinning. Cotton Polyester Blend: From the cotton and polyester blend where the recycled cotton can be used instead of virgin cotton. Polyester blend can be used as the polyester fiber gives strength. To use the recycled fabric for workwear, even knit and woven design combination can be brought together as there would be stress and strain in the woven fabric. Those areas in the garment like elbow, back shoulder knitted fabric can be used which would facilitate the workers to carryout the work. This knitted portion can be of reused pre-consumer waste which needn't be recycled.

The required anthropometric measurements are to be taken and considered for the design development of the workwear after studying the work type and work movements. The following is the flow chart of the methodology.



The aesthetic aspect is not the important criterion in the work wear but its focus has to be given to the ergonomic aspects and the strength of the garment and the ease of movement to facilitate the work that will be carried out in the industry.

4. Conclusion:

Many technologies are coming up and several research are being carried out. Reusing and recycling are preferable options rather than creating new products which are then disposed as landfills or incinerated. Recycling of yarns also have to undergo a lot of process in which the yarns would lose its strength. So, now ring spinning have been found out to be a preferable option with comparatively finer yarns which can be used to make apparels and home furnishings. Designing workwear from pre-consumer textile

waste blend is challenging where further inventions and research is required to make finer yarns with better strength.

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