Waste Management in Textile Industry

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Introduction

The existence of human beings on earth is the result of a fortuitous set of circumstances in which conditions for development of the species were present so that evolution could take place allowing us to reach our present state of being. Our tenuous continuation could be jeopardized at any time by changes in these conditions, and this far-reaching effect could result from shifts which might be totally insignificant by cosmic standards. They could bring about, for example, our inability to breathe, or stay warm or cool enough, or grow the food we need. Thus, we are only able to survive because our planet provides all the sustenance we need without major effort on our part. We can broadly define this set of conditions to which we are exposed as our environment. One of the minor ways by which we reduce the risk of premature extinction is to guard our bodies from excessive temperature fluctuation by the use of textiles. Textiles are also used to make life more comfortable or convenient for us. Without them, we would find life harsher, and probably not survive with the same life expectancy as we do now.

Textiles are manufactured to perform a wide range of functions and are made up of different types of fibres mixed in varying proportions. In general, applications of fibers belong to the following three broad categories: apparel, home furnishing, and industrial. Most of the fiber products are for short term (e.g. disposables) to medium term (e.g. apparel, carpet, automotive interior) use, lasting up to a few years in their service life. While the textile industry has a long history of being thrifty with its resources, a large proportion of unnecessary waste is still produced each year. Commercially, textile waste generation is influenced by the production of textile goods, higher the production, the greater the amount of waste. This is in turn a function of consumer demand, which is influenced by the state of the economy. While this may have a limited impact on the waste production in the manufacturing sector, it can have a much greater influence on the production of household textile waste. Consumers react to changes in fashion both in clothing and household interior designs. Seasonal changes in fashion mean that clothes can become outdated very quickly, and this encourages the replacement and disposal of outdated, yet good quality garments. Consequently, manufacturers will increasingly develop high quantities of low durability clothing in response to a 'throwaway society'. Economic prosperity also influences this trend, as the production of textiles increases with consumer spending, so does waste production from both the manufacturing and household sectors.

The management of waste is a formidable problem. However, the overall guiding principle, agreed by everyone, to protect the environment is to 'reduce, re-use, repair or recycle', and actual disposal of waste should be a last resort. Types of Textile waste. Textile waste can be classified as either pre-consumer or post consumer waste; Pre-consumer waste consists of byproduct materials from the textile, fiber, and cotton industries that are re-manufactured for the automotive, aeronautic, home building, furniture, mattress, coarse yarn, home furnishings, paper, apparel and other industries. Post consumer waste is defined as any type of garment or household article made from manufactured textiles that the owner no longer needs and decides to discard. These articles are discarded either because they are worn out, damaged, outgrown, or have gone out of fashion.

Waste Management

In general, there are four ways of handling the waste. In order of priority, they are:
1. Source Reduction
2. Landfills
3. Recycling
4. Incineration

Source Reduction

To have little or even zero waste Source Reduction is generally the first step that should be considered in an integrated waste management system. E.g. avoiding waste generation, internal reuse of waste, reuse in other products etc

Incineration: It is a process of burning the solid waste to recover the heat energy. E.g. PP has same heat vale as that of gasoline. Textile waste e.g. short, shredded, loose fibres can also be reincorporated into a palatalized fuel. But, Incinerator chimneys emit organic substances such as dioxins, heavy metals, acidic gases and dust particles, which are all potentially harmful to both humans and the environment. Also, there is a problem disposing of residual ash which is likely to contain a concentration of toxic material.

Land Fills

It should be the last alternative in an integrated Waste management system. Textile waste in landfill contributes to the formation of leachate as it decomposes, which has the potential to contaminate both surface and groundwater sources. Another product of decomposition in landfill is methane gas, which is a major greenhouse gas and a significant contributor to global warming, although it can be utilized if collected. The decomposition of organic fibres and yarn such as wool produces large amounts of ammonia as well as methane. Ammonia is highly toxic in both terrestrial and aquatic environments, and can be toxic in gaseous form. It has the potential to increase nitrogen in drinking water, which can have adverse effect on humans. Cellulose-based synthetics decay at a faster rate than chemical-based synthetics. Synthetic chemical fibres can prolong the adverse effects of both leachate and gas production due to the length of time it takes for them to decay.

Recycling

Recycling is a key concept of modern waste management. Recycling is the reprocessing of waste materials into new or reusable products. Ninety-nine percent of used textiles are recyclable. In many applications, especially where metals, glass or polymers (including synthetic textile materials) are involved, the recycling process can only slow down damage to the planet. The least expensive and least adverse effect on the environment is when a component can be recycled into its original product, i.e. so called 'closed loop' recycling. The second best is when it can be used in another article which usually requires less demanding properties, for example face car seat fabric being recycled into backing material. Typically, recycling technologies are divided into primary; secondary, tertiary. Primary approaches involve recycling a product into its original form; secondary recycling involves melt processing a plastic product into a new product that has a lower level of physical, mechanical and/or chemical properties.

Tertiary recycling involves processes such as pyrolysis and hydrolysis, which convert the plastic wastes into basic chemicals or fuels

Advantages of Recycling

- Recycling system uses 20 percent less energy and reduces carbon dioxide emissions.
- Reducing environmental load through the efficient use of resources and energy and the recycling of used products.
- Individuals are doing more than promoting the health of the environment through recycling.
- Recycling include petroleum savings, greenhouse gases reduced, energy conserved.
- Reduces the need for landfill space. Textiles present particular problems. In landfill as synthetic (man-made fibers) products will not decompose.
- Reduces pressure on virgin resources.
- Aids the balance of payments as we import fewer materials for our needs.
- Results in less pollution and energy savings, as fibers do not have to be transported from.

Designing textile products for easy recycling a great challenge in the design of products that are easy to recycle is seen in the development of ecofriendly Products. Waste should be avoided both in the production process and when disposing of products.

In addition, material substance should, at the end of product life, be suitable to be returned into the material cycle (recycling).

Products consisting of only one material in a single system (non-composite) are easy and pure to re-use. With them, it is not generally necessary to separate the product structure prior to processing. This is why single-material systems are preferable when it comes to the design of products easy to recycle.

Combinations of different kinds of textile made from the same polymer (e.g. PP fibre material and PP film or coating) are single-material composite systems, which are also easy to recycle. If the required characteristics of a product are not achievable using but one material, multi-material composite systems are necessary. Systems containing separable composites need to be disassembled prior to recycling, which can be done manually or by machine. This is what happens, for example, to non-textile functional elements used within garments, and to technical textiles.

Processes such as glueing, laminating or stitching result in composites which cannot be separated. With regard to complete re-use, the materials chosen should go well together so they can be processed together. Currently, processing makes sense as long as the secondary raw material produced can be well marketed.

If the materials used in a multi-material composite system do not go together and if they are not separable from one another, they may serve as a fuel or as a raw material (generation of energy or of synthesis gas)

From all this results textile products that are designed to be easy to recycle, characterized by:

- **The potential to be disassembled and**
- **The potential to be re-used or disposed of**

The recycling of resources can be broadly divided into thermal, material and chemical sectors. In the fiber and textile industry, thermal recycling is intended to recover heat energy generated from the incineration of fiber wastes as thermal or electrical energy. This method, although easily practicable, does not mean the recycling of resources. Material recycling recovers polymers from fibers or plastics, and at present, the idea of transforming polyethylene terephthalate (PET) into fibers is most economical and widely used for practical purposes. But there is concern about this method which is apt to let impurities mix into recovered polymers, resulting in declined quality and spinning stability. Chemical recycling recovers monomers from waste fibers by polymer decomposition. This is the method of the future. Impurities can be easily removed from recovered monomers, so their quality will be made exactly equal to virgin monomers. An important consideration in all three sectors is to establish an economical collecting system and an efficient recovery technology and to develop commodities using recovered materials. The key point of material and chemical recycling in particular is how to collect and separate wastes. In this context, it may be argued that the development of those products that can be easily recycled will be an important task to be carried out in the years ahead.

Recycling of garments

- **Seed Clothing Markets**
- **Recovery from the waste stream includes re-use of a product in its original form. The largest volume of goods is sorted for second hand clothing markets.**
- **Conversion to new products**

Two categories of conversion to new products will be used here.

i) **Breakdown of fabric to fiber** Shoddy (from knits) and mungo (from woven garments) are terms for the breakdown of fabric to fiber through cutting, shredding, carding, and other mechanical processes. The fiber is then re-engineered into value added products. These value-added products include stuffing, automotive components, and carpet under lays, building materials such as insulation and roofing felt, and low-end blankets.

ii) **Re-design of used clothing**: The other category for conversion to new products is the actual re-design of used clothing. Current fashion trends are reflected by a team of young designers who use and customize second-hand clothes for a chain of specialty vintage clothing stores

- Wiping and polishing cloths Clothing that has seen the end of its useful life as such may be turned into wiping or polishing cloths for industrial use. T-shirts are a primary source for this category because the cotton fiber makes an absorbent rag and polishing cloth.

- Mechanical processes to recover fibres

With mechanically compacted nonwovens blends of chemical and natural fibres or with pure natural-fibre, the mechanical opening-up of the textile structure by means of breaking them down is carried out. The manufacture of reclaimed fibres is wide-spread and economical. Although the fibres, to a certain degree, are physically damaged in this process, the functional components of the fibrous material are maintained. One advantage of the process is it can be applied with both production waste and material nonwovens after their use.

Re-granulation

All the type of waste from thermoplastic fibres such as polyethylene, polypropylene, polyamide, polyester etc. can be processed on agglomeration plants so as to make free flowing granulates. The granulate can also be used to produce fibres (generally, for lower-value application). Important characteristics for the workability of granulates are sufficient melt viscosity, bulk density and flow ability. They can be used as heavy-insulation layers (sprinkled onto or sintered onto the backs of moulded parts or floor covering) or as a powdery binder agent to substitute phenolic resin when producing thermally bonded nonwovens and mats.

- Production of textile chips and their application Nonwoven waste may be made into textile chips. One may cut, mill or shred it. Most preferably, textile chips can be made of edges of material in the place where they occur. Above all, edges of thermally bonded nonwovens, of nonwovens used to produce moulded parts or of coated nonwovens are well suitable for the purpose Textile chips can be added as auxiliary material to produce textile concrete.

- Processing nonwoven waste on **KEMAFIl** machines Nonwoven waste in the form of material edges, section bobbins or refuse material can be used in the **KEMAFIL** process as a valuable textile material for the production of a huge range of cord products. In the **KEMAFIL** process, such rope-like waste is embedded as core material in the centre of a coat of loop threads which is created by means of special tools. They are used for uses in agriculture, industry and the building industry, to make irrigation and drainage ropes, sensor lines, welts, verbound protection ropes

Re-use of nonwoven waste: Re-use is the use of a product no more suitable for the original purpose without any or just small material modification for a new application. E.g. re-use of textile covers of paper-making machines to improve foundations in road construction and civil engineering.

Recycling of synthetic fibres:

- Chemical Methods Depolymerisation, Reprecipatation, hydrolysis, Glycolysis etc
- Thermal Route Hard waste (polymer blocks) and PET bottles are granulated, filament waste is compacted, and drawn filament waste is shredded or cut.
- Mechanical Waste Processing The filament waste is cut in a cutting mill granulator, between a rotary knife and a fixed knife. The sieve insert, having a square mesh

opening of 12-20mm, determines the size of the waste granulate which is pneumatically transported away.

- Yarn to Staple Processing Spun or POY yarn residues on tube can be taken off overhead from a creel, plied, drawn and crimped in a one stage process. During processing, new waste packages can be knotted or spliced into the running tow. A staple cutter is employed for cutting. Then the staple is pneumatically conveyed to a bale press, where it is compressed, baled and strapped.
- **Solvent Extraction**: It is generally used for carpet recycling. In this process, a consecutive chain of solvent is used to remove polymers of interest. E.g. Acetone & Hexane are used to remove oils; ethylene dioxide is used to remove PVC plastics etc.
- **Cyrogenic Fracture**: In this method, with or without mechanical or ultrasonic vibrations, the temperature of polymers is reduced to below glass transition temperature with liquid nitrogen or other cold temperature materials which make the coating or film brittle. Polymers are then broken & separated.
- **Pyrolysis Kiln**: It is a thermal decomposition of organic material in an oxygen deficient environment. This technique is used for the production of fuels & chemicals from organic feedstock such as waste tires
- **Powdering**: Here high pressure at low temperature is used to grind the material for further processing. Generally, it is in the manufacturer's interest to keep production waste as little as possible. Easy-to-take measures as seen from the technical/technological point of view are, optimization of available production plants to better exploit the material in the production process optimization of the products with regard to recyclability (choosing the right materials and technologies) optimization of the production technology, e.g. choosing the optimum point of time to cut edges or process control when changing quality or assortment.

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