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POLYETHYLENE TEREPHALATE (PET)- A NEWER AND ENDURING STRATEGY FOR VALUE ADDITION IN THE TEXTILE INDUSTRY

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ABSTRACT
Increasing polyester waste is a global problem, and many studies have indicated that most of the waste goes to landfills. Due to the increased environmental awareness, there is a strong trend to reduce the generated amount of solid wastes and attempt to recycle them. Recycling of plastic can reduce the generated plastic waste of the environment. Therefore, the recycling of plastic can have a positive impact on the surrounding environment. One such a new strategy has been conducted in recent years to up cycle the plastic waste, in order to add value and re-use them as new and sometimes high-end items. Various studies reported that plastic waste can be processed into energy, gases & oil. One such recycling method was developed by researcher where PET fibres are also recovered from plastic waste. Nowadays, various types of recycled textile products: clothing, sportswear, agricultural nets and nonwoven are also being produced by using PET fibres. The recycled PET fibres recovered from plastic waste can be reused as a renewable feedstock in the next textile production cycle.
Keywords: Environment, Fibres**,** Land Fills, PET, Plastics, Recycling, Sustainable, Textile industry, Waste**.**

I. Introduction
Over the past decade, there has been a tremendous increase in the amount of wastes which is generated by human beings. Wastes are mostly of two types- organic & inorganic. Organic wastes are biodegradable. It can be decomposed by micro-organisms. While inorganic waste is a waste that cannot be broken down by micro-organism, contributes significant pollution in environment [1]. The forms of inorganic waste can be plastic, plastic bottles, packaging of many other products like milk, spices, edible oil, bread, confectioneries, rice, wheat flour, snack foods and various types of medicines [2].
Plastic has remarkable physical and chemical characteristics. Because of these properties it become a major commodity in worldwide and has so many applications in industries [3]. Plastic have also made significant contribution in every field of human activity today like agriculture, medical, transportation, piping, electrical and heat insulation, packaging, manufacturing of household and electronic goods, furniture and other items of daily or specific use [4]. However, the use of plastics comes with many harmful environmental impacts. Plastic waste contaminates all major ecosystems on the planet, with concern increasing about its potential impacts on human health and wildlife [5].
The UN estimates that the whole world produces around 400 million tonnes of plastic waste every year. According to the report by the EU, 520kg waste was produced per person per year in 2003 which would be 680kg by 2020 where 40kg per person produce plastic related wastage that is approximately 7-8% by weight [6]. Ashwini Kumar Choubey, a minister of the Ministry of Environment, Forest and Climate Change, told to the Lok Sabha that around 34.7 lakh tonnes per annum (TPA) of plastic wastes was generated by India during 2019-20. He also added that 15.8 lakh TPA of the plastic waste was recycled and 1.67 lakh TPA was co-processed. Which makes it 50% of the total plastic waste produced recycled [7].
Plastics as carbon-based compounds have several toxic components which can have harmful effects on environmental and public health. People in modern packaging industries frequently use plastic materials. When the wastage of these materials is not well disposed of, it causes serious health issues to the public health in both direct and indirect ways [8]. The plastic wastes, when combined with other antigens or foreign bodies in animals like human beings and cattle, the physiological

functioning of animals is influenced in different ways, and animal's digestive systems cannot digest the plastics [9]. Plastic wastes also toxify land due to the chemical degradation of its organic decomposition [10]. When plastics wastes are dumped in the land the ultimate result would be the risks of contamination of soil and groundwater [11]. Land dumping of plastics wastes reduces the fertility of soil that affects plants and other animals [12].

Due to the increased environmental awareness, there is a strong trend to reduce the generated amount of solid wastes and attempt to recycle them. Recycling of plastic can reduce the generated plastic waste of the environment. According to the data given by Noone, most of the PET (polyethylene terephalate) that was recycled had been transformed into fibers as shown in **Figure 1** [13]. PET fibers are classified into two types: staple fibers and partially oriented yarn (POY). They possess distinct material characteristics and are used for different end-use applications. Consequently, because they are essential intermediary products in the nonwoven and textile sectors, recycled PET staple fibers and POY are extremely important [14].

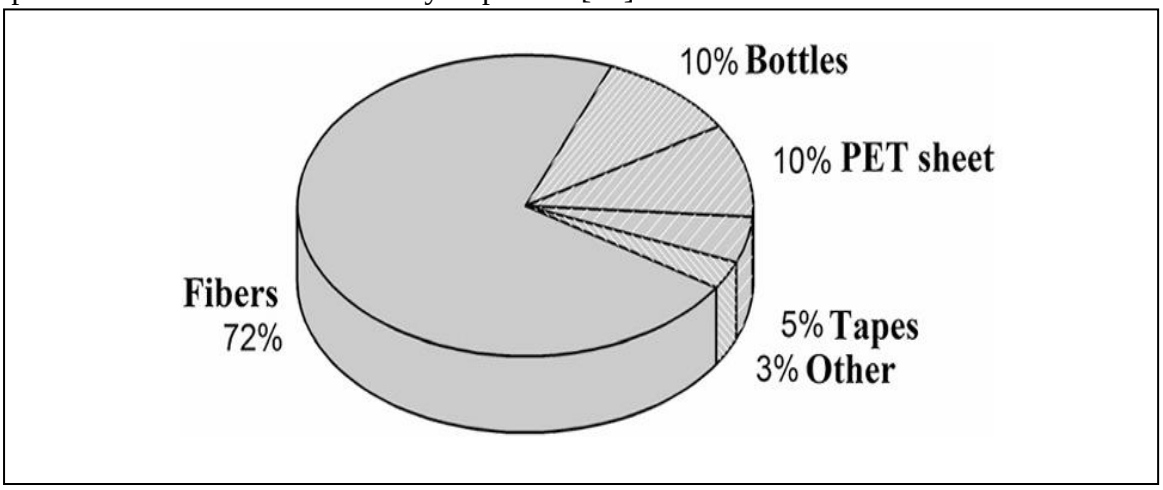

Figure 1: Applications of recycled PET flakes [13]

II. Type of recycling process

Since the price of virgin PET is constant and economical, it is important to develop an affordable method for PET recycling [14]. Converting of PET flakes into PET fibers can be carried out by two different processing approaches, such as chemical recycling and mechanical recycling.

In the case of **chemical recycling**, the old plastic is broken down into its original monomers by means of glycolysis, hydrolysis or methanolysis. These monomers are then used to manufacture new plastic granulate through polymerization. To this end, the quality of the recycled product is very close to that of new materials and it can be used to spin high-end yarn. Compared to mechanical recycling, the chemical procedure requires greater energy consumption. Due to the high capital investment requirements, this option is only available to large-scale manufacturers.

In **mechanical recycling**, the plastic waste is melted directly without any chemical decomposition. The melt can then be either processed directly into the end product or first granulated into chips. To this end, the waste is shredded, melted and re-granulated. This process can simply be reintroduced to the production cycle [14-15].

However, a new strategy has been conducted in recent years to up cycle the plastic waste, in order to add value and re-use them as new and sometimes high-end items. Various studies reported that plastic waste can be processed into energy, gases & oil. Nowadays, various types of recycled textile products (like PET felt), clothing, sportswear, agricultural nets and nonwoven are also being produced by using plastic wastes [16].

III. PET felt

PET (polyethylene terephalate) felt, is an innovative material invented from a desire to combat plastic pollution. PET Felt is made from discarded plastic waste by undergoing a meticulous process that transforms it into a felt-like material with an array of applications [17]. Plastic bottles are collected, compressed, shredded, and melted down to create granulate, or plastic flakes. The flakes are soft fibres which are pressed together in layers to make a sturdy sheet of PET [18]. The fabric made out of the PET is ten times stronger than a normal polyester fabric. But to weave or knit the yarn made out of PET bottles needs very heavy machines and till now Europeans have mastered in this technology and the looms/knitting machines are very expensive. PET is fully recyclable. Polyethylene terephthalate (PET) is a versatile material and has a wide range of applications such as acoustic panels, sheets and films, straps, engineering resins, food and beverage bottles, bottles, packaging materials, reinforcement in building construction, etc. [19-21].

IV. How does plastic bottle turns into PET felt or apparel?

It all starts when PET bottles are tossed into recycling bin. These bottles are sorted at a recycling facility and bundled together in large bales. The bales of PET bottles are then taken to a PET reclaiming facility. The bottles are thoroughly cleaned, the labels and caps are removed, and the bottles are separated by colour (the clear bottles will produce a whitish yarn and the green bottles produce a greenish yarn) [15].

Once they're sorted, the bottles go into a grinder where these are grinding into small flakes. The flakes are tossed in hot air to give them a hard candy coating and then dried to remove any remaining moisture. After the drying, crispy flakes are shoved through hot pipes to melt them into a thick liquid. That liquid gets filtered through a plate with 68 tiny holes. As the liquid polyester flows through the holes, it forms filaments that are more than five times finer than human hair. The filaments cool and harden and are then sent over rollers where air entangles the filaments to create a dental floss-like yarn. The machine spools the yarn and then pulls it over hot metal rollers to stretch it and realign the polyester molecules. The resulting yarn is ready to be woven into clothing [15]. Rajasthan Teen's Startup converts 1,000 Kg plastic waste to fabric every day as shown in Figure 2 [22] and steps of making PET felt or apparel is shown in Figure 3 [23].

Figure 2: Conversion of plastic waste to fabric every day [22]

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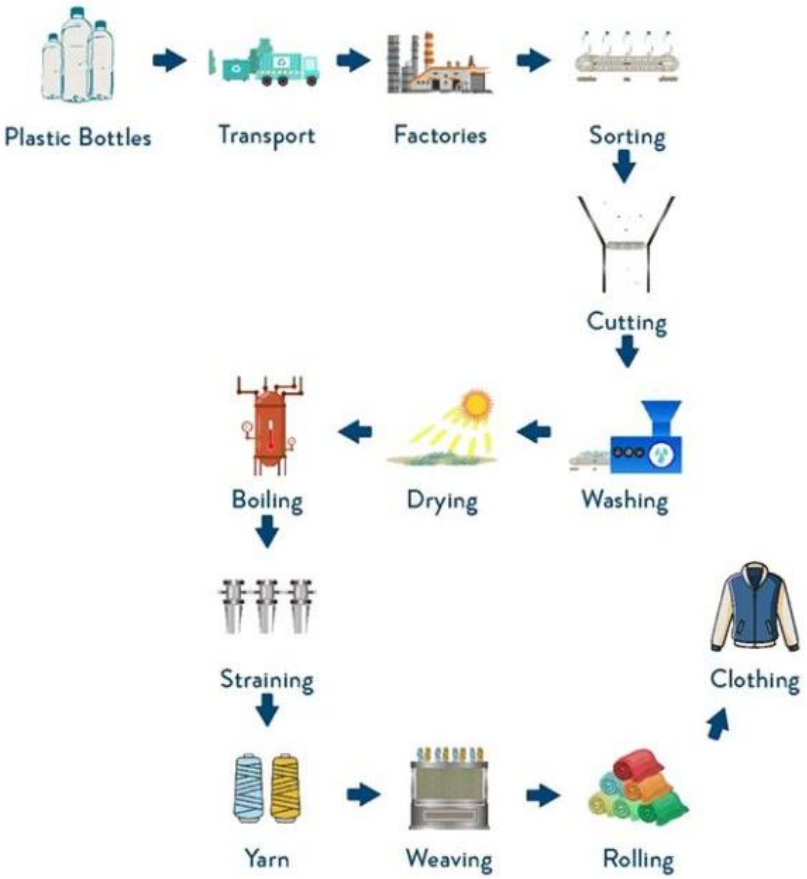

Figure 3: Steps of making PET felt or apparel [23]

V. The manufacturing process chart

The manufacturing process chart of the PET felt described step wise below in Figure 4 [24]:

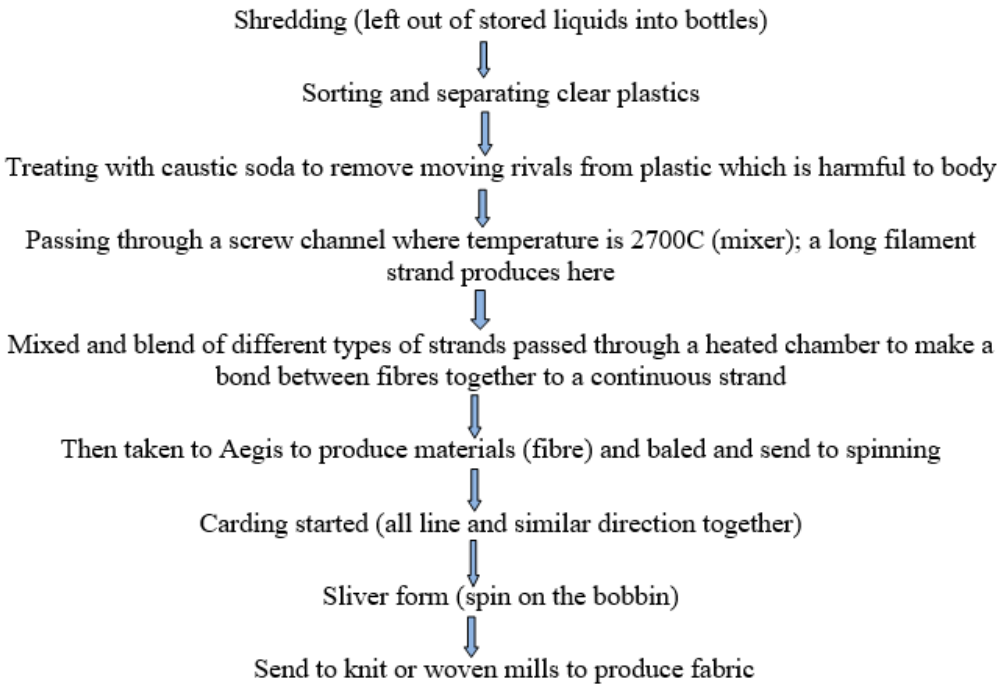

Figure 4: The manufacturing process chart of the PET felt

VI. Benefits of PET felt and apparel-

PET felt and apparel is responsible for reduction in toxins released into the air while burning waste plastic as well as the waste bottles dumped into the landfills are also reduced. Further, the used plastic bottles which are turned into fabrics are recyclable and they generate less pollution in the environment. There are few important advantages of PET felt and apparel are given below:

6.1 Reduced landfill waste

PET felt and apparel is made from old plastic bottles, diverting waste from landfill and reducing demand for virgin materials. Through this ending up in landfills of waste can be prevented [25].

6.2 No virgin materials

As a recycled fabric, PET does not rely on virgin materials. This means a lot of less consumption of crude oil and gas, which is used in the formation of regular polyester. If we were to switch all polyester to PET felt and apparel, there would be less demand for this non-renewable resource [25].

6.3 Energy efficient production

PET felt and apparel uses less energy compared to making clothes from virgin polyester. The Swiss Federal Office for the Environment says PET felt and apparel textile uses a massive 59% less energy to create compared to regular polyester fabric [25].

6.4 Lower CO_2 emissions

It takes much more power to produce virgin polyester from crude oil and gas. There is also no need for additional oil to create the material. WRAP estimates that the production of PET felt and apparel reduces CO_2 emissions by 20.7% compared to regular polyester. This means a lower carbon footprint.

6.5 PET felt and apparel is ethical and durable

PET felt and apparel is usually more ethical than regular polyester. This is because the supply chains which recycle the fabric are more transparent, especially when compared to conventional fabrics where it can be incredibly difficult to trace the origins of a garment. One of the reasons polyesters has been so popular for decades is because it is durable. Similarly, recycled polyester fabric is strong and durable, ideal for clothes, bags, and performance gear.

6.6 PET felt and apparel is versatile and affordable

There are many different products that are made from polyester - bags, clothing, shoes, upholstery, and many more. This fabric turns waste plastic bottles into a range of products we wear and use. PET felt and apparel fabric is often more affordable when compared to many other sustainable materials. Ultimately this makes it more accessible to a wider range of customers, which will help bring about a sustainable fashion revolution.

6.7 Easy to care & Quick-drying

Polyester is considered for easy to care. PET felt and apparel can be machine washed at a lower temperature, requiring less energy through its consumer lifecycle. PET felt and apparel is quick drying, just like regular polyester. This is why it's perfect for outdoor and athletic wear.

6.8 Breathability & Moisture wicking

PET felt and apparel is engineered to be breathable, allowing air to flow through the threads of the fibre quickly and easily. This prevents build-up of moisture and heat, and allows for moisture wicking. Polyester is well known for its moisture wicking property, making it an excellent choice for athletic wear and active clothing. There's a reason it's used in sports clothes so much [25].

6.9 UV protection & UV resistance

Polyester fabrics usually provide sufficient UV protection (UPF 30+), while other fabrics such as cotton, linen, and viscose frequently offer poor UV protection. Different from UV protection, polyester fabric has a good resistance to UV rays. This means the material won't break down or lose its colour when exposed to the sun for long periods of time.

6.10 Colourfast

Colours don't fade in recycled polyester fabrics. This is because the material can easily be dyed into a wide range of colours. This is especially true when compared to fabrics like regular cotton, which takes a lot of processing to bleach and eventually dye into the colours.

6.11 Promotes a circular economy

PET felt and clothing promotes a circular economy. It raises awareness of the need for change in the fashion industry. If more of us expect fast fashion retailers to use sustainable fabrics like recycled polyester, they need to change. This is how we can do our bit to promote a more sustainable future.

VII. Conclusion

The fashion world has embraced the concept of recycled clothing from plastic bottles. Hence, it is common to find recycled plastic garments in stores anywhere in the world. Today, one can find garment manufacturers using PCR (Post Consumer Resin) and coming up with clothing line for men, women and children. Moreover, the plastic spun thread can be blended with other fibres to create variety of clothing for every section of people [26]. Recycled bottles are used for various purposes. One such use of this recycled material is spinning it into thin fibers, which are used to make clothing such as T-shirts, jackets, shirts and garments for exercise usually made from polyester blends. Soft fleece is made from these bottles which are used for hats, blankets and jacket linings. There are brands that make warm, comfortable, weather resilient and long-lasting clothing with recycled plastic bottles. This is a great way to cater to the needs of people as well as eliminate waste from the environment.

Although PET is a relatively new material, its versatility, affordability, and convenience contribute to its rapid growth in India. It is thus both a challenge and an equal opportunity for the PET recycling infrastructure currently in operations in India. The Indian societies likewise globally are on a learning curve in their usages, handling and disposal of PET packaging. The industry is benefitting from better PET waste management.

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