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EXPERIMENTAL INVESTIGATION ON PET BOTTLES INTO FABRIC

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Abstract

Textile is a massive industry all over the world and fibers are the basic need of textiles. Polyester is a synthetic fiber made from a non renewable resource, is well known for its environmental impacts during its extraction and manufacturing process. Poly ethylene Terephthalate (PET) is a part of polymer family which is commonly used for packing and has a great recycling value. The PET bottles are shredded into small flakes and are extruded. The extruded PET flakes form a liquid. The melted liquid will be allowed to pass through spinnerets which produce the long thread like structure which will be crimped to form staple fiber. Staple fiber undergoes yarn production process resulting in polyester yarns. The recycling process provides better sustainability and protects environment.

Keywords: *Poly ethylene Terephthalate, Polyester, Spinnerets, Staple fiber.*

I. INTRODUCTION

1.1. General

The major problem faced by present generation is about the disposal of waste. Many approaches have been made to solve this issue and some have become a great success. But till date no methods or ideas have been implemented achieving a 100% result. The major cause for this drawback is the exponentially growing population.

The day-by-day increasing land pollution is mainly due to Municipal Solid Waste (MSW). In these MSW, plastics play a major role for causing land pollution. Not just land pollution but plastic also share a major contribution in climate change. A sharp increase in greenhouse gas emission from the petro chemical industry including plastic threatens to climate benefits.

Water bodies like ocean suffer a great impact due to the accumulation of waste like plastic. Polyethylene terephthalate (PET) bottles and plastic covers almost fill and pollute the ocean bodies. These plastic was considered as food by aquatic organisms and are consumed. When they are consumed the fishes suffocate to death. Also plastic disintegrate as micro particles and these particles pollute water bodies.

1.2. Polyethylene Terephthalate

PET consists of polymerized units of the monomers "ethylene Terephthalate" with repeating units. Poly ethylene Terephthalate is the common thermoplastic polymer resin of the polyester family which is either used as fibers for clothing or containers for liquids and foods.

The majority of PET materials are utilized by textile industry as polyester from virgin plastic while the rest of the production is hooked up with the production of bottles. PET bottles are globally present and they are partially recycled under closed loop process as bottles again or end up in environment as polluting factor of land, ocean and even atmosphere.

Table 1 Properties of Poly ethylene Terephthalate

S.No	Property	Value
1	Technical name	Poly ethylene Terephthalate
2	Chemical formula	$(C_{10}H_8O_4)_n$
3	Melt temperature	260^0C
4	Injection mould temperature	$74 - 91^0C$
5	Tensile strength	152 MPa
6	Flexural strength	221 MPa
7	Specific gravity	1.56

1.3. Polyester

Polyester is a category of polymers that contain the ester functional group in the main chain. Polyester is a generalized term for any fabric or textile, which is made using polyester yarns or fibers. Some of the characteristics of polyester fabric are

- Polyester is very durable and is resistant to many chemicals.
- This is a popular fabric in the fashion industry, as it is resistant to shrinking and stretching. It is also resistant to wrinkling and abrasions.

1.3.1 Use of polyester

Industrial polyester fibers are also used in things like:

- Conveyor belt fabrics
- Seat belts
- Sports wears
- Plastic reinforcements and more.

1.4 Objective of the project

The basic rule of sustainability for choosing a raw material must be that, it should not extinct the source of the material. Even if its extinction is determined, the material should be in the category of elimination. I see this project as a turning point to end the polluting era of plastic. The main aim of my experimental project includes the following:

- To analyze the generation of PET bottles in India and its end life strategies. By analyzing the generation data the raw material available for the production of yarns can be calculated.
- The objective of this project is to reduce the amount of plastic that end up in land and ocean.
- Create a new product out of plastic which mitigates the impacts of plastic pollution.

II MATERIALS AND METHODOLOGY

2.1. Materials required

Requirements that are needed to carry out this project is PET bottles. PET bottles are widely used all over the world. The overall PET bottle generation in India is about900 kilo tons per year. Collection was done in the local region of Coimbatore from certain scrap dealers. Around 1 Kg of bottles are collected which amounts 25 number of one litre and 35 number of half liter bottles. An average half litre bottle weights around 9.9 g while an average one liter bottle weights around 19.8 g. In exact around 1.1 Kg of waste PET bottles were collected.

2.2 Methods

Conversion of PET polymer into polyester fiber is a simplified process that requires a little specification for perfect output. Usually PET is recycled by

- Mechanical recycling
- Semi mechanical recycling
- Chemical recycling (re polymerization and de polymerization.)

2.3. Mechanical method

Mechanical method is where the every single stages of the process are handled in continuous steps using machines.

- The PET bottles which are the raw material will be collected and sorted.
- The sorted bottles will be inserted into a shredder which will shred the bottles and other PET containers into tiny pieces of flakes.
- These flakes are tiny pieces of poly ethylene Terephthalate. Flakes will be present along with some

impurities such as labels, mixture of bottles with other plastic types, dust etc,.

- In order to remove these contaminants, the flakes are well sterilized.
- The sterilized flakes are inserted in a melt extruder where they undergo thermal decomposition at a temperature of 260^0C.
- After undergoing thermal treatment the extruded liquid will be allowed to flow through spinnerets.
- Spinnerets produce fine filaments or staple of polyester fiber which will undergo the process of yarn production.

2.4. Semi-mechanical method

Semi mechanical method is almost similar to the mechanical method.

- The raw materials are collected and sorted out.
- After being sorted, they are finely shredded by a plastic shredder, producing tiny pieces of flakes.
- These flakes are washed and sterilized directly in order to remove foreign particles like labels, impurities and other plastic contaminants.
- The sterilized flakes are allowed to dry and inserted into an extruder.
- Inside the extruder, the flakes undergo thermal decomposition at a temperature of 260^0 C and are converted into pellets.
- Pellets or granules are transported or stored and used for later processing.
- These pellets are extruded again in melt extruder again and are forced into spinnerets and follow the production of yarn.

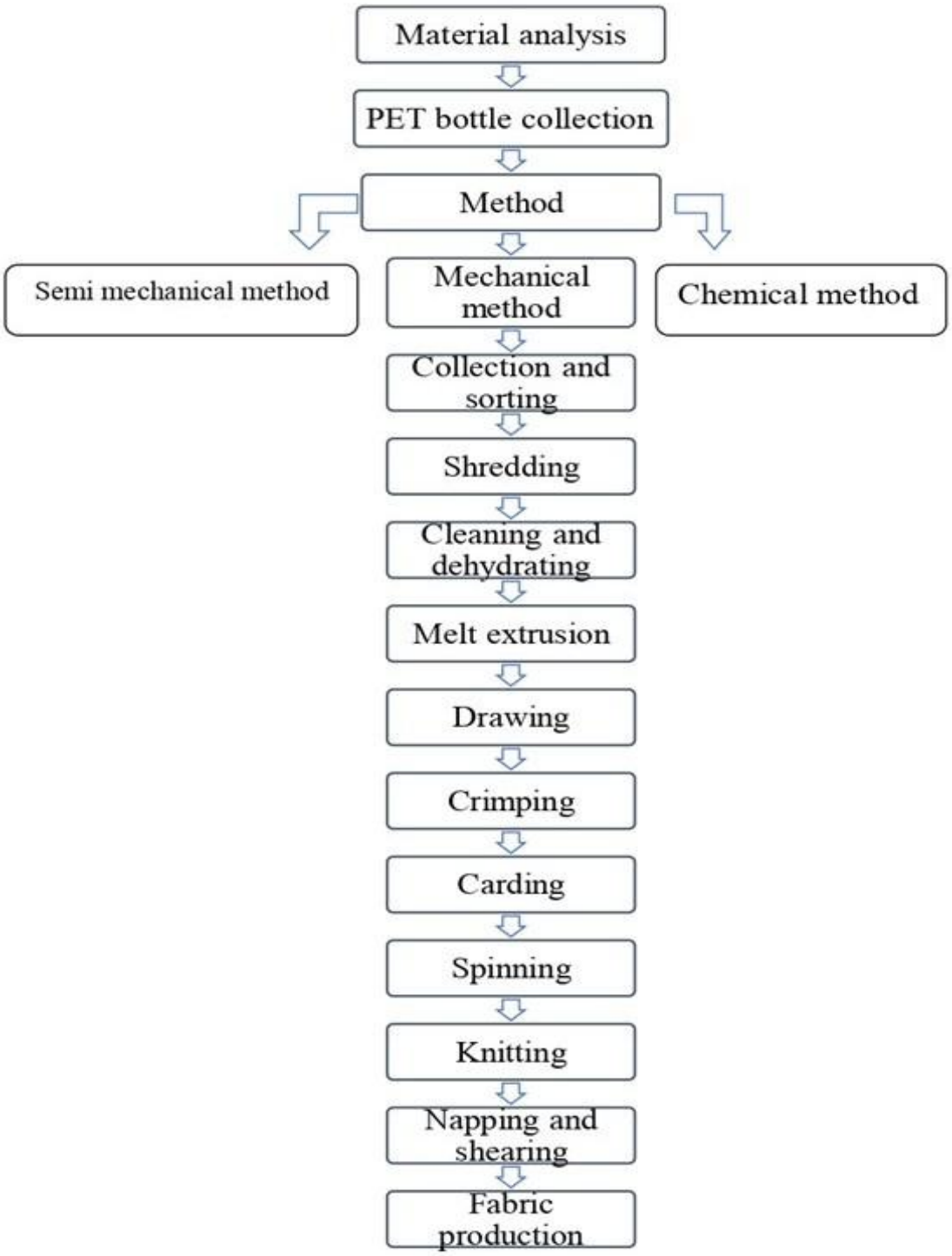

Figure 1 Flowchart for the production of fabric

2.5. Collection and sorting

Collection is the process of gathering or collecting the raw materials required for the process. Bottles that have been discarded as waste and are collected from scraps and dump sites.

Sorting is the simple process of separating the substances that are not required for the process from the desired

raw materials i.e. other than Polyethylene Terephthalate is separated.

Figure 2 Bottles and containers collected from household and scrap

2.6. Shredding

Shredding is the process of producing raw materials to be reintroduced into manufacturing where the materials are finely shredded to tiny particles. Shredders are specifically designed for larger plastics to be reduced into flake like structures.The bottles are washed and made into tiny flakes using a shredding machine. A shredder is a machine used to cut down any substance into tiny flakes so that proceeding with the material is made easier.

Figure 3 Shredded forms of collected PET bottles

The plastic bottles are crushed into tiny pieces of flakes. These flakes are washed again to ensure the purest possible final product is achieved. These flakes become the raw material for the production of yarn. The sizes of the flakes produced are measured to be in two to three centimeters.

2.7. Melt Extrusion

Melt extrusion is the process of applying heat and pressure to melt a polymer and force it through an orifice which is known as spinneret. A spinneret is a device used to form fibers from the extruded polymer solution.

Streams of viscous polymer exit through the spinneret into air leading to phase inversion

The boiled PET flakes are heated under pre defined temperature in an extruder. An extruder slowly heats the flakes as the rotational phase of the extruder moves, the flakes are taken to higher temperature where they

slowly tends to melt. As for Poly ethylene Terephthalate the melting temperature is 260^0 C. The hot liquid is extruded through very fine holes in a metal disk called a spinneret. The fibers which are solidified will be wounded on a heated spool. At this point, the fibers form something like a thick rope, which is called tow. The rope-like bundles of polyester that emerge are called tow.

Figure 4 Shredded flakes are melting

2.8. Drawing

Drawing or drafting in yarn manufacturing is the process of attenuating the loose assemblage of fibers, by passing it through a series of rollers. This method straightens the individual fibers and makes them parallel. Drawing reduces a soft mass of fiber to a firm uniform strand of usable size..For producing fibers from plastics, stretching process is applied to fibers increasing orientation and reducing size.

The tow is next pulled through the heated rollers of a drawing machine to three or four times its original length. Drawing increases the strength of the fiber, and helps set the crystalline structure of the PET molecules into smooth strings.

2.9. Crimping

Crimping is the process carried out to give the fiber more texture and to increase its insulation property along with its elasticity. The tow then passes through a crimping machine, which compresses the tow and gives it a crinkled, accordion like texture. This also adds strength.

Figure 5 Staple fibers produced after crimping

The crimped tow passes to a dryer, and then is cut into lengths of a few inches of staple length and baled. At this point, the short, fluffy, hairy fiber looks very much like wool.

2.10. Carding

Carding is a mechanical process that disentangles, clean and intermix the fiber to produce a continuous web or sliver suitable for subsequent processing. Fibers are tested for uniformity of strength and thickness. The cut tow is sent to a carding machine, which aligns the fiber into thick, rope- like strands known as sliver.. The sliver also follow the process of combing and again drafting is carried out.

2.11. Spinning

Spinning is the process of drawing out and twisting fibers to join them together in a continuous thread or yarn. The strands flow out of the machine and are coiled into barrels or open containers. The thick ropes are then fed into a spinning machine. The spinning machines twists the strand in a much finer diameter and collect the finished yarns onto the huge spools This way yarn is produced from waste PET fibers.

2.12. Knitting

Knitting is the process of creating a fabric by manipulating yarn by creating multiple loops of stitches in a line or tube interloping the dried yarn is next fed into a particular kind of mechanical knitter called a circular knitting machine. The knitting machine binds the yarn into a continuous tube of cloth. The tube may be approximately 58 in (1.47 m) wide and several hundred yards long..

The knitted fabric is coloured as per the desire of the product. Disperse dyes are the only water soluble polyester that can dye polyester and the knitted materials are dyed.

2.13. Napping and Shearing

Napping is the raised surface on a textile that is a result of brushing loose staple fibers out of the fabric structure. The nap makes the fabric feel softer and traps air that serves as insulation.

Technically, napping is the finishing process that raises the fiber on the fabric to produce a mat of fiber ends or nap, which are commonly used on knitted fabric made of staple fibers.

Shearing, in textile manufacturing is the process of cutting the raised nap of a pile fabric to form a uniform height to enhance the appearance of the garment. Shearing machine operate much like rotary lawn mowers, and the amount of shearing depends on the desired height of nap or pile. Shearing may be applied to create stripes and other patterns by varying surface height.

Figure 6 Recycled polyester fabric

The knitted material is next fed through a napper. The napper runs mechanical bristles along the cloth, raising the surface of the textile. Next, the cloth is sent to a shearing machine, which uses a precision blade to cut the fibers raised by the action of the napper. This same process is used to make velvet, corduroy, and other textured pile fabrics

III EXPERIMENTAL INVESTIGATION

3.1. Testing of Fabric

The fabric made out of the recycled polyester needs to be checked, so that the capacity or strength it can withstand can be identified. A readymade virgin polyester fabric is collected and it is tested along with the experimentally made fabric out of recycled PET bottles, so that both the virgin polyester and recycled polyester can be compared.

3.2. Shrinkage Testing

Shrinkage on fabric is mainly due to yarn swelling and the result crimp increase during washing. In order to test the shrinking the following procedure is done;

- Cut a square fabric of 40cm from a roll and draw a square 40cm X 40cm on the fabric.
- Measure the fabric before washing
- Wash the fabric with the standard washing procedure and let it dry.
- Apply the fabric shrinkage formula

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$$\text{Shrinkage \%} = \frac{(\text{Width before Shrink} - \text{Width after Shrink}) \times 100}{\text{Width before shrink}} \qquad \text{Equation (1)}$$

Apply this test on both virgin fabric and recycled fabric. The observation of shrinkage test on recycled fabric is noted as

Initial length before boiling (i) = 40 cm

Final length after boiling (f) = 37.5cm

Shrinkage % of the test fabric $= \frac{-f}{i} \times 100$ Equation (2)

Therefore,

Shrinkage % of the fabric $= \frac{40 - 37.5}{40} \times 100$

Shrinkage % of the fabric = 6.25%

A standard virgin polyester cloth of same length is tested and the result is observed as

Initial length before boiling (I) = 40 cm

Final length after boiling(F) = 36.2 cm

Shrinkage % of the fabric $= \frac{I - F}{I} \times 100$ Equation (3)

Therefore,

Shrinkage % of the fabric $= \frac{40 - 36.2}{40} \times 100$

Shrinkage % of the fabric = 9.5%

Table 2 Shrinkage test

Polyester samples	**Initial length (cm)**	**Final length (cm)**	**Shrinkage Percentage (%)**
Virgin polyester	40	36.2	9.5
r-PET polyester	40	37.5	6.2

This proves that recycled polyester resist shrinkage than virgin polyester. This resistance can be due to the irregular arrangement of cross linked polymer.

IV. CONCLUSION

The raw material commonly used for polyester yarn production is replaced by the PET bottles that ends up as a waste.. The only difference in replacing the PET bottles is the initial step of pellet to filament. The energy used to convert the Poly ethylene Terephthalate into filamentous liquid is 2600C of heat. These yarns have been highly utilized in the practical field of apparels and textiles since they are cost efficient. The machineries used in the production of polyester yarns is almost similar to the machineries used for the production of recycling Poly ethylene Terephthalate.

From my experiment, it was inferred that the technology of Polyethylene Terephthalate can be successfully recycled into the field of textile and apparel rather than dumping landfill and ocean just by making some difference in existing working technology of polyester yarn production.

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