

RECYCLING BY EXTRUSION

What
&
How



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INTRODUCTION

Now that we've discussed the basics of chemical recycling and mechanical recycling, we will now move on to extrusion. While chemical and mechanical recycling can be used for most textile materials, extrusion can only be applied to thermoplastic materials (e.g. polyester, polyamide, and polypropylene).

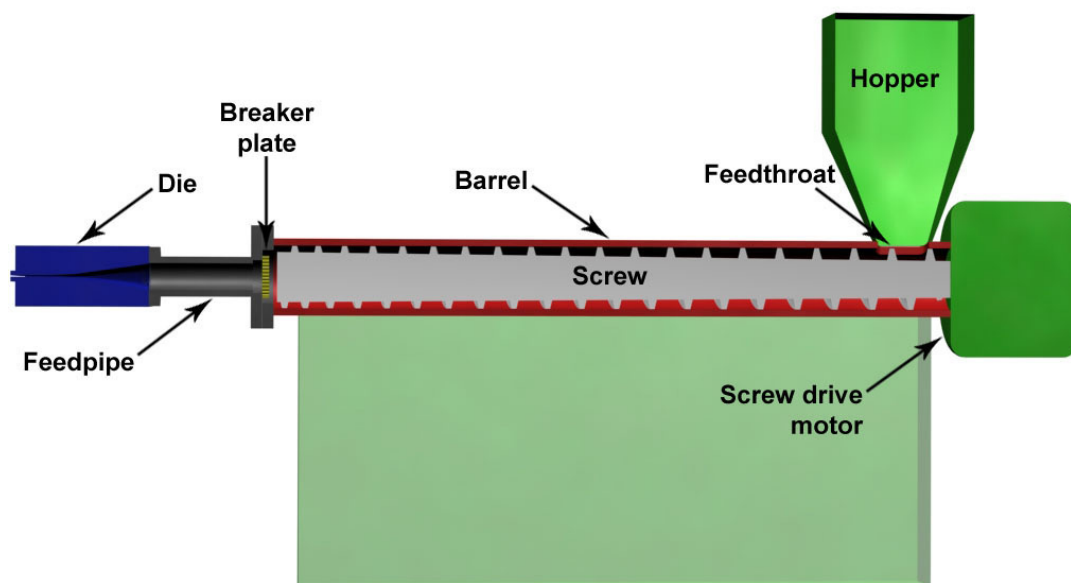
In essence, extrusion is the process of forcing a pliable material through a hollow die with a fixed shape. This versatile technique is used for everything from the industrial manufacture of pipes to the creation of certain types of pasta. Because plastic is a malleable material when heated, extrusion is frequently used in the plastic industry.

RECYCLING PLASTIC BY EXTRUSION

The recycling process begins by converting meltable polymer waste materials into plastic granules. An extruder, the machine that performs the extrusion process, is made up of the following basic elements:

- a feeder (also called a hopper)
- a screw, which transports the material through the extruder
- a heating system to melt the thermoplastic material
- a slot die (by which the material leaves the extruder)

An example of a simple extruder is shown in the drawing below.



Above: A sectional view of a plastic extruder. Plastic granules are melted and then fed into the hopper. The melted plastic is then fed through the barrel and extruded through a die. Photo was released into the public domain by its author and was retrieved from Wikipedia in June of 2020.

INPUT TEXTILES FOR RECYCLING BY EXTRUSION

Recycling by extrusion is only possible using pure thermoplastic fibres (e.g. polyester, polyamide, and polypropylene). Blends of thermoplastic fibres cannot be processed if the flow properties of the molten materials and/or their melting temperatures are too far apart (they must fall within a range of approximately 10-20 °C).

The thermoplastic fibre waste should be clean and free from non-meltable contaminants. Metal components (e.g. zippers, push buttons and rivets) should, therefore, be removed before the product can be extruded. Examples of textile waste that can be recycled by extrusion include:

- women's polyester blouses
- polyester sportswear (mostly 100% polyester multifilament, which cannot be processed by mechanical recycling)
- polyamide workwear (like Cordura, which is a polyamide 6,6 fibre)
- fishing nets
- polypropylene nonwovens (often used in disposable protective clothing)

Recycling textile waste by extrusion is not an option for natural fibres (e.g. cotton, wool and viscose), for most textile blends, or for coated fabrics.

PRETREATMENT FOR RECYCLING BY EXTRUSION

Recycling by extrusion requires well-prepared input material. The input material must be entirely composed of specific thermoplastic fibre. Non-meltable materials (eg. natural fibres, coatings, and metal parts) must not be present.

Because extrusion takes place at high temperatures (well above the melting point of the thermoplastic fibre), special precautions must be taken to avoid undesirable side effects during the process. The most important preventative measure is ensuring that the material is dried to a very low level of residual moisture (0.1 gram water per kg) before extrusion. Water at high temperatures will decompose most thermoplastic polymers during extrusion (due to depolymerisation).

Before being fed to the extruder, the textile waste material has to be cut in small pieces and turned into small compressed balls or pills. Otherwise, a special kind of extruder, called double-screw extruder, must be used.

THE EXTRUSION PROCESS

In the first part of the extrusion process, the thermoplastic material is melted. The screw in the extruder then slowly transports the material through the extruder, while also mixing and homogenising the material. The colours of the input material are also mixed during this phase.

Sorting materials based on colour will result in a homogeneous colour, but colour variations often occur. By adding master batches of concentrated coloured thermoplastic material, a more uniform (but darker) coloured re-granulate can be obtained. For polyester, other reactive agents (e.g. chain extenders, which repair broken molecules) might be added to the extruder to improve the quality of the output.

At the end of the extruder, the material is cooled down to just below its melting point before leaving the extruder through the slot die. The shape of the opening of the slot die (usually circular) determines the shape of the recycled thermoplastic string that comes out of the extruder. The resulting string is then cooled down further using either air or water.

THE OUTPUT OF THE EXTRUSION PROCESS

The output of an extruder is a string of thermoplastic material with a diameter of a few millimetres, which is then chopped into small pieces a few millimetres in length. This material is called the regranulate and can be used for further processing. Further processing might include the extrusion of textile monofilament yarns (with a diameter of 100-500 micrometres), but this is only possible if the regranulate is very pure (without any foreign particles) and has a diameter bigger than half the diameter of the monofilament.

More often, the regranulate is used in the extrusion of larger products (like pipes and rods), or in injection moulding wherein the molten regranulate is pressed into a mould. The shape of the mould determines the end-product. Regranulate thermoplastic materials are used to produce products like flowerpots, crates, toys, plastic chairs and more.

In conclusion, only very pure thermoplastic textile waste materials can be recycled by extrusion. The method is well suited for discarded textile products made out of 100% pure thermoplastic material (like multifilament polyester shirts). Thermoplastic fibre recycling resembles the recycling of plastics in many ways. The resulting regranulate can only be used to produce thermoplastic textile fibres under special circumstances in which the input materials are sorted very precisely.

THE DO'S & DON'TS OF TEXTILE RECYCLING

- Reuse, repair and refurbish textile products as often as possible.
- Buy second-hand textile products in shops and through apps.
- Always discard unwanted textiles at a textile collection bin. Make sure your donated items are clean and dry.
- Textile waste is always suitable for recycling, but it is not always possible to reuse textile waste in the textile industry.

DID YOU KNOW? SUSTAINABILITY & EXTRUSION

Although limited to thermoplastic fibres, extrusion is quite sustainable as a recycling technology. Did you know that most recycled polyester textiles are not actually made from recycled textiles, but recycled PET bottles?

Every hour, millions of these bottles are discarded worldwide. When these bottles are recycled by extrusion, the resulting regranulate is good enough for the production of textile fibres. Many fleece jackets and vests are made from these recycled PET bottles.



Above: Thermoplastic textile waste must be sorted prior to recycling by extrusion. Sorting materials based on colour will result in a more homogeneous colour, but colour variations often occur.

WANT TO KNOW MORE?

Have we piqued your curiosity? If so, you can check out some of the resources and references below to find out more about recycling by extrusion.

RESOURCES

- [Manufacturing of fabric by recycling plastic bottles](#) - an article from Textile Focus.
- [Making Shirts Out Of Recycled Water Bottles](#) - a video from Sand Cloud, a sustainable fashion brand, about making fabric from PET bottles

REFERENCES

Extrusion. (n.d.). Wikipedia. Retrieved June 2020 from <https://en.wikipedia.org/wiki/Extrusion>

Plastic Manufacturing. (n.d.). The Warren. Retrieved June 2020 from <http://www.the-warren.org/GCSERevision/engineering/plastic%20forming.htm>

Image: Sectional view of a plastic extruder showing the components. (n.d.) Wikipedia. Retrieved June 2020 from https://en.wikipedia.org/wiki/Extrusion#/media/File:Extruder_section.jpg

**ALTHOUGH LIMITED
TO PLASTIC FIBRES
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IS ACTUALLY
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**MANY FLEECE JACKETS
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#facts&figures