

An Introduction to Single Screw Extrusion

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Single Screw Extrusion

Extrusion is a process used for creating a product (an extrudate) by forcing a material through a die or an orifice to form a shape, or alternatively an extruder is used to produce semi-finished or finished products.

This article mainly focuses on the extrusion of thermoplastic products due to their importance in extrusion processes. Undoubtedly, thermoplastics are the largest group of plastic materials extruded; almost 65% of all plastics pass through an extruder.

As the single screw machine is the most popular type of extruder, this article focuses on processes based on this type of machine. As single screw machines are relatively cheap, simple and easily provide a continuous output, they are very popular.

Extrusion and Thermoplastics

In a thermoplastic extrusion, the material is first softened by heating so that it can be shaped. This process is performed by the extruder, or extrusion machine. This heat softening is referred to by different names, such as 'thermal softening', 'plasticization', or 'plastication'.



extrusion forming, and the product is then set to shape by cooling while maintaining its shape. The equipment used to perform this process is known as the post extrusion equipment, while the entire system is known as an extrusion line.

Extruder Classification

Extruders may be categorized by three figures, for instance, 1-60-24. The first number specifies the amount of screws the machine has, the second number indicates the screw diameter in millimeters (mm), and the third number indicates the effective screw length as a multiple of the screw diameter. Therefore, in the given example, a single screw machine is being described that has a screw diameter of 60 mm and a length of 24 (i.e., a L/D ratio of 24/1).

Machine Construction

Figure 1 shows a cut-away diagram of a simple single screw machine. This diagram shows the arrangement the different parts of the machine. The two units - screw and barrel - interact together to convey the plastic material, melt the material, and then push it through the die.

The screw is rotated at a predetermined speed with the electric motor drive unit and gearbox. Temperature controllers are connected to heating/cooling elements on the barrel to maintain the temperature at the set-point temperatures.

The capability of the screw and barrel assembly to extrude a given material is based on the characteristics or construction of the barrel and screw, the characteristics of the plastics material, and the circumstances under which the system is operated.

Most extruders are single screw machines. The screw is what forces the material towards, and then through, the die. Shape is imparted by the die, and/or by post-

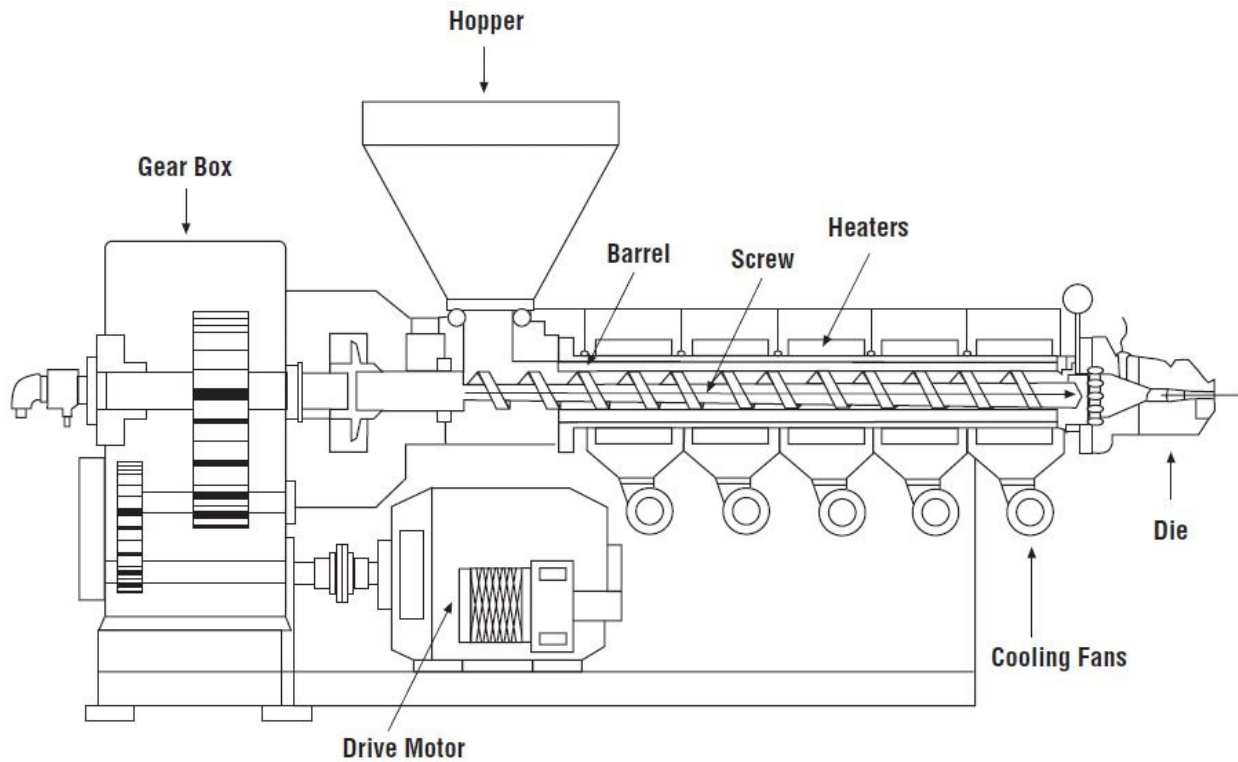


Figure 1. Single Screw Extruder (courtesy of Dr. Harold Giles)

Post Extrusion Equipment

When the extrudate leaves the die, it can either be set to the desired shape or its shape can be altered and then set to shape. The equipment that performs this process is known as the 'post extrusion equipment' or the 'haul off', and in terms of size, it is generally much larger than that of the extruder. This is because plastics take a considerable amount of time to cool, and this cooling process determines the speed the line will operate.

Products of Extrusion

The extrusion products include:



- **Plastic Film:** This is generally used for packaging or sealed into bags.
- **Plastic Tubing:** Used for tubing and hose for laboratories, automobiles, etc.
- **Plastic Pipe:** Used for water, drains, gas, etc.
- **Plastic Insulated Wire and Cable:** Used in the industry and home for appliances, for communications, electric power distribution, etc.
- **Feedstock for Other Plastics Processes:** Extruders are widely used as compounders, or mixers. The output from an extruder compounder is chopped or granulated to form the feed for another process, such as extrusion or injection molding.
- **Plastic Coated Paper and Metal:** Used for packaging.
- **Sheet:** Used for lighting, glazing, signs, etc.
- **Filaments:** Used for ropes, twine, brushes, etc.
- **Nets:** Used for soil stabilization, packaging, etc.
- **Profile:** Used for home siding, gaskets, windows, doors, tracks, etc.

Co-Extrusion

Co-extrusion is a process that allows two, or more, melt streams to combine in a die to make an extrudate from two or more materials. This process is now linked to thermoplastics materials, although it was first used with rubbery polymers to make an extrudate with layers of different colors. With thermoplastics, the layers of material are often combined in the die.

The simplest example combines only two layers, for instance a colored layer on a natural core, which saves on colorant costs. Films based on three or more layers are common in the packaging industry. Laminating two or more different polymer layers together can result in a product that has better barrier properties than those obtained when only a single polymer is used.

One of the polymers frequently used is a moisture or gas barrier layer based on polyvinyl alcohol (PVAL). Usually, two or three extruders are used to produce three-layered structures. In the blow-molding process, co-extrusion and bi-axial orientation can possibly be combined to produce lightweight yet strong bottles that extend the storage life of products.

Layered co-extrusion is not the only form of co-extrusion. A sequential co-extrudate can be produced by combining the materials one after the other. This may include a hard thermoplastic material combined with a soft thermoplastic material. Alternatively, two materials can be extruded side-by-side, for example, a clear material together with an opaque material, to produce a sheet for making thermoformed trays.

Vented Extrusion

A vented extruder consists of a vent, which is used to extract volatiles from a plastic material during the extrusion process. Using a vented machine, the water (moisture) and volatiles content present in a plastic material can be reduced to satisfactory levels.

Part of the way along the extrusion barrel, the diameter of screw root is reduced to decompress the melt. At this point, a vent, through which the vapor escapes, is located in the barrel (when venting is not needed, the vent may be plugged and not used). Then, the vapor-free melt is sent towards the die and re-compressed by increasing the diameter of the screw root.

A dam or torpedo section is integrated on the screw just before the vent to make sure that melt does not escape through the vent. Due to the design and operation of the vented machines (a variable screw geometry and a high L/D ratio), it has been observed that these produce excellent mixing.

However, it must be remembered that it would be more appropriate to pre-dry the polymer, because heating certain plastics in contact with water may degrade or decompose them.



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