



# EXTRUSION: AN OVERVIEW

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**E**xtrusion is simply an act of forcing material through a die. High cooking temperature, pressure, and moisture transforms the raw material into cooked and formed products.

There are several functions/actions that take place during the short time. Several types of extruders are used for the manufacturing feed and pet foods.

Some are single screw, some are twin screw, some have internal steam locks, some have grooved barrels, some have continuous flighting, and others have interrupted flighting. Some extruders generate their own heat by friction for cooking and other use additional heat sources like steam for cooking purpose. All these extruders work depends upon the application.

Due to the abrasive nature of feed and pet food, proper selection of the materials of construction is important to minimize operating costs. If screw and barrels wear too frequently, the costs of operating an extruder may become prohibitive and ultimately lead to shut down of the extruders.

Extruders are not new. Very short L/D (barrel length/diameter) high shear extruders for making puffed snack foods have been manufactured for over 70 years, single screw cooking extruders for nearly 35 years and co-rotating twin screw extruders for 40 years. Presently, extruder manufacturers are trying to make these extruders more efficient and less expensive. There are approximately 25 major extruder manufacturers domestically and overseas.

## Function of an Extruder:

The conditions generated by the extruder perform many functions that allow it to be used for a wide range of food, feed and industrial applications. Some of these functions are:

**Agglomeration:** Ingredients can be compacted and

agglomerated into discrete pieces in an extruder process.

**Degassing:** Ingredients that contain gas pockets can be degassed by extrusion processing.

**Dehydration:** During normal extrusion processing a moisture loss of 4-5 percent can occur.

**Expansion:** Product density (i.e. floating and sinking) can be controlled by extruder operation conditions and configuration.

**Gelatinisation:** Extrusion cooking improves starch gelatinisation.

**Grinding:** Ingredients can be ground in the extruder barrel during processing.

**Homogenisation:** An extruder can homogenise by restructuring unattractive ingredients into more acceptable forms.

**Mixing:** A variety of screws are available which can cause the desired amount of mixing action in the extruder barrel.

**Pasteurisation and Sterilisation:** Ingredients can be pasteurised or sterilised using extrusion technology for different applications.

**Protein denaturation:** Animal and plant protein can be denatured by extrusion cooking.

**Shaping:** An extruder can make any desired shape of product by changing a die at the end of the extruder barrel.

**Shearing:** A special configuration within the extruder barrel can create the desired shearing action for a particular product.

**Texture alteration:** The physical and chemical texture can be altered in the extrusion system.

**Thermal cooking:** The desired cooking effect can be achieved in the extruder.

**Unitizing:** Different ingredient lines can be combined into one product to give special characteristics by using an extruder.

## Advantages of Extrusion

The principal advantages of the food extrusion technology as compared to the other food processing techniques include:

**Adaptability.** An ample variety of products are feasible by changing the minor ingredients and the operation conditions of the extruder. Extrusion process is remarkably adaptable in being able to accommodate the demand by consumers for new products.

**Product characteristics.** A variety of shapes, texture, color and appearances can be produced, which is not easily formed using other production method.

**Energy efficient.** Extruders operate at relatively low moisture while cooking food products, so less re-drying is required.

**Low cost.** Extrusion has lower processing cost than other cooking and forming processes. According to some references we can save 19 percent raw material, 14 percent labor, and 44 percent capital investment. Extrusion processing also need less space per unit of operation than other cooking system.

**New foods.** Extrusion can modify protein (vegetable and animal), starches (almost all sources), and other food material to produce a variety of new and unique food products.

**High productivity and automated control.** An extruder provides a continuous high-throughput processing and we can have a fully automated controls for these extruders.

**High product quality.** Since extrusion is HTST heating process, it minimises degradation of food nutrients, while improving the digestibility of proteins (by denaturing) and starches (by gelatinizing). Extrusion cooking at high temperature also destroy the anti-nutritional compound, i.e. trypsin inhibitors, gossypol, hemagglutinins, and undesirable enzymes, such as lipases, lipoxidases and microorganisms.

**No effluent.** Very few process effluent are produced.

## Classification of Extruders

**Single-Screw Extruder:** Single-screw cooking extruders have compressive screws with decreasing channel depth turning at high speeds to increase shear and mechanical energy input for heating. Heating of product is induced by the resulting friction. The barrel is jacketed for steam to allow additional contact heating in the metering section. To increase capacity and efficiency, it is common to preheat ingredients in a preconditioner by adding steam before they enter the extruder. Categories of single-screw extruders, includes:

**Cold forming (Pasta-type) extruder:** deep flight, smooth barrel, low shear speed. Little or no cooking. Used for pasta, pastry dough, cookies, egg-rolls, ravioli, processed meat and certain candy.

**High-Pressure Forming Extruder:** grooved barrels to prevent slip at the wall and greater compression in the screw design. Used for pre-gelatinized cereal and fried snack foods.

**Low-Shear Cooking Extruders:** moderate shear machines with high compression machines and grooved barrels to enhance mixing. Soft-moist foods, and meat like snacks such as simulated jerky.

**Collet Extruders:** high shear machines with grooved-barrels and screw with multiple shallow flights. Used for puffed snacks and expanded curls or collets.

**High Shear Cooking Extruders:** high shear machines, with screws of changing flight depth, HTST devices. Make pet food, Ready-to-Eat Cereal (RTE), candy, crisp breads, precooked food ingredients, pre-gelatinised corn flour, dried food mixes,

instant beverage powder, croutons and breading, crackers and wafers, enzymes deactivation of full fat soy flour, imitation nuts, famine relief feeding, texturised vegetable protein (TVP), and deactivation of enzymes in cereal and oilseeds.

**Twin-Screw Extruders:** Twin screw consist of two parallel screw in a barrel with a figure-eight cross section. The use of twin-screw extruders for food processing started in the 1970s, with an expanding number of application in the 1980s. Twin screw extruders are generally one and one-half times or more expensive than single screw machine for the same capacity. Yet the degree of quality control and processing flexibility they offer can make them attractive to food industries. Twin screws produce a more uniform flow of product through the barrel due to the positive pumping action of the screw flights. Some other

advantages of twin screw are:

- Handle viscous, oily, sticky or very wet material and some other products which will slip in single screw extruder, ( It is possible to add up to 25 percent fat in a twin screw extruder)
- Less wear in smaller part of the machine than in single screw extruder.
- Wide range of particle size (from fine powder to grains) may be used, whereas single screw is limited to a specific range of particle size.
- Because of the self-wiping characteristics cleanup is very easy. Four type of twin-screw extruders are possible:
  1. Non-intermeshed, co-rotating
  2. Non-intermeshed, counter rotating
  3. Intermeshed, co-rotating
  4. Intermeshed, counter rotating

From these four types of twin-screw extruders, co-rotating, intermeshed screw type has found the widest acceptance in food and feed industry.

### Single Vs. Twin-screw Extruder

Single-screw extrusion has been successfully employed in food and feed production over the last 75 years. Because of consumer demands for innovative food products in the market,

extruder manufacturers adopted developed twin-screw extruders approximately 45 years ago.

Twin-screw extruders have greater ability and flexibility for

controlling both product and process parameters. They are

a flexible design permitting easy cleaning and rapid product changeover. Because of ability to better match the desired shear, the twin-screw extruder has more control over product variability.

Screw speed also can be used to compensate for some variations in the properties of the starting material. The twin-screw extruder is a better choice for plants producing a wide variety of high-value products at low volume because the screw speed is such an influential variable.

Single-screw extruders are limited to 12-17 percent fat level in the formula. Fat above that level reduces friction because of lubrication and does not help the hardware transform mechanical energy into heat for cooking purposes. On the other hand, fat level in the recipe for Twin-screw extruders can be as high as 18-22 percent and still maintain the mechanical energy. This is only possible because of more screw configuration options with twin-screw extruders compared to single-screw machines.

In single-screw extruders with the help of steam injection, fat level of the recipe can be achieved as high as 17 percent, but the same recipes with the addition of steam in twin-screw extruders will process more consistently, which in result has better binding of the fat in the product and reduces the leakage of fat from the products during handling and packaging.