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Technical Article: "Extrusion principles for production of Pellets for Snack food"

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The process of Extrusion consists of production of continuous uniform shape like ring, circles, hexagonal and other profiles, pipe, rod, etc. This process is very commonly used to produce products from various plastic/rubber and and is also used for production of extruded pellets from food cereals like wheat, maize, rice, potato, etc. into various shapes. These pellets are usually expanded afterwards, by hot air or fried in oil for complete expansion. The extruded pellets are characterized with high levels of starch (over 65-75%) in them which results in very high expansion when heated in hot air or fried in hot oil. Snack food produced in this manner are termed as "third generation snacks" or "In-direct expanded products" since they need external heat for complete expansion, after being extruded as pellets.
The extrusion technology is also applied for producing pregeled starches from corn, tapioca, etc.

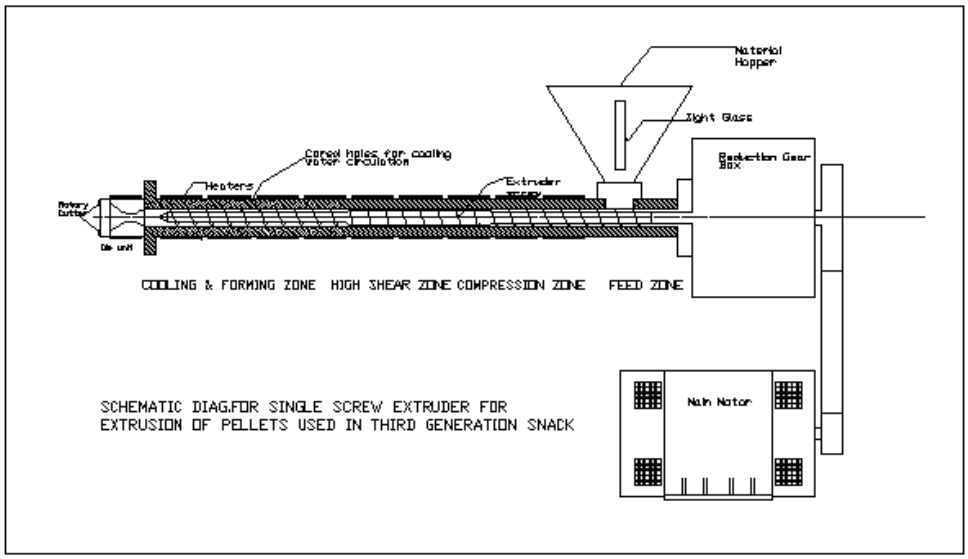
Examples of Snack Pellets:

There are two types of Extrusion processes that are used for production of pellets- 1) Single screw Extrusion 2) Twin screw Extrusion.

Single screw Extrusion:

In this process, as the name suggests, a single screw Extruder is used. The Extruder consits of a single screw with four zones designed on it is used: the feed zone, the compression or kneading zone, the

cooking zone, and the cooling (forming) zone. The screw rotates inside a smooth bore electrically heated cylinder (barrel). The barrel is electrically heated externally by means of temperature controlled band heaters fitted around the barrel. In addition, water cooling jackets are fitted round the barrel for cooling by water to raise the viscosity of dough & maintain conditions required for proper production of the pellets. See diagram below:



The screw is rotated via reduction gear box and variable speed motor. A feed hopper is provided near the feed zone on the barrel, in which the food cereals premixed with moisture and other ingredients like emulsifiers, shortening, processing aids, proteins, flavours, etc. are loaded. The food material is picked by the rotating screw and conveyed as well as compressed (cooked) as it travels forward towards the exit end of the barrel fitted with a die with the desired shape. The food material is cooked, because of the screw design where the volume of flights is gradually reduced either by reducing the depth of flight or by reducing the pitch of screw flight. The feed zone with a deep cut flight (or large pitch) has greater volume, hence imparts very little or no shear, while the cooking zone with shallow flight depth (or lesser pitch) has lesser volume hence imparts greatest shear to material. The compound is cooked due to the combined action of the heat supplied from the heaters fitted round the barrel, as well as the mechanical working by the rotating screw. The temperature and shear are highest at the cooking zone and viscosity is low. As the cooked plastic mass travels forward through the Cooling (Forming) zone, it is maintained at very low shear rate and is cooled to raise its viscosity for final discharge through the die. The product is immediately cut into small lengths, at die face by rotating cutting blades working against the die, and the cut pellets fall below on a conveyor which transports the product to a drier for drying the moisture from the pellets, to a level required for safe packing.

The single screw Extruder design employs a High shear screw design to cook the compound, followed by a low shear cooling/forming zone to cool and pump the ingredients through the die at proper temperature and shear. It is also common (and better) to use two separate extruders: one for cooking and other for cooling the cooked mass. The cooking extruder is provided with heaters, while the cooling extruder consists of a larger diameter screw and provided with cooling arrangement to cool the compound and pump the cooled mass through the die opening. The latter arrangement yields more productivity, since functions of cooking and cooling are done on two separate extruders, and their speeds can be individually adjusted whereas if one single extruder is used for both these functions, it

results in a long screw and conflicting requirements- high speed is needed for cooking zone and low speed at cooling zone since minimum shear is needed in the cooling zone. Since it is not possible as the cooking and forming zones are designed on one common screw shaft, it usually results in low output because screw rotational speed is set low to avoid excessive shear in the forming zone. However, despite this, a single extruder is used because of economy and lower initial investment.

For Hygeine of extruded product, it is very important that all contact parts including screw, barrel and die, be made in Stainless steel.

Raw materials: Pellet products can be made from single source of starch, such as corn flour, or from a blend of cereal grains. The main requirement is adequate level of starch to provide structure when puffed in hot oil or air.

Blending and Pre-conditioning:
Before the ingredients are fed to Extruder, they need to be blended and pre-conditioned in suitable pre-conditioner.
Most common raw-materials used in pellets for snack food are: Starch in form of wheat, corn flour, tapioca, potato, etc., liquid shortening (vegetable oil upto 2.5%), required level of moisture (approx. 25-35%) (water), emulsifier such as mono glyceride (0.4-0.8%). If required, other ingredients like proteins, flavours, fibres etc. may also be added. Nucleating agents may be added to get fine cellular and surface texture on the expanded product, since these are insoluble and do not melt in processing and provide nucleating sites where the water vapour formed during frying is released to get cellular appearance on product. Nucleating agent concentration is upto 1.5% and most commonly baking powder is used.

The ingredients are pre-mixed in a pre-conditioning vessel for proper mixing and moisture (water) is preferably sprayed over the ingredients to assure proper absorption and penetration in the individual particles. The preconditioning blender consists of a Ribbon blender with spiral blades for proper mixing and pre-conditioning of the food materials. Usually, no pre-cooking is done in the pre-conditioner but certain pre-conditioners will also precook the ingredients, for e.g by steam injection. The vessel and blades are made from Stainless steel.

Processing:
In the Extruder, the temperature of material is maintained from 100-150 °C. The feeding zone tempt. On the barrel being maintained at lower tempt. To ensure proper feeding of materials to the successive zones, tempt. Is gradually raised in successive zones, from 100 to 150 ° in the cooking zone to cook the food materials. It is necessary to maintain the barrel temperature profile above gelatinization temperature of starch, unless pregelled or precooked ingredients are used. It is important to understand, that, the melt viscosity drops as the temperature is increased, but after critical temperature, the viscosity again rises and ir-reversible state is reached, i.e the compound cannot be re-softened once this state is reached. In contrast, in plastic extrusion, the melt viscosity keeps on decreasing with the application of heat and upon solidification, the mass can be re-heated to re-soften and melt it. But this is not so with extrusion of food cereals. Hence precise temperature and shear controls are necessary in food extrusion.
In the forming (cooling zone), the temperature of material is maintained at 100-110 °C. To attain cooling densification of visco elastic mass before being forced out of the die opening. The total residence time of food materials in the extruder is approx. 15-25 seconds.
Since the product still contains excessive moisture as it is cut at die, the pellets are immediately transferred to hot air drier where the moisture content is reduced to around 10-12% for safe handling and storage. The wet pellets should be maintained at 85-95 deg in the drier for 2-3 hours to evaporate excessive moisture.

Twin screw Extrusion:

Though single screw extruders are still being used for producing pellets, they have limitations since there is excessive pressure flow and leakage flow losses because of inherent design of process and single screw has definite limitations to transport stick/gummy masses. Twin screw extruders are widely employed for extrusion of pellets because of their several visible advantages:

1) In twin screw extruder (TSE), 2 co-rotating (rotating in same sense) are used which intermesh fully and are self wiping in operation. Thus there is no hold-up area where the material can accumulate and degrade. Single screw extruder is more difficult to clean.
2) The TSE is a positive machine, in that there is no or very little flow losses inside the barrel. In contrast, the single screw extruder has very high flow losses inside which results in drastic reduction of the output available.
3) The twin screws are made up as separate segments, comprising of feeding screws, kneading blocks and cooking and pumping elements assembled on central shafts. It is possible to change the screw configuration & length to achieve best processing conditions for raw materials. No such benefits are available with single screw design, since screw is made as a solid unit.
4) The quality of product is generally better when TSE is employed for pellet production.
4) Due to above advantages and also increased throughputs, the high cost of TSE extruder usually repays back fast.

Like in single screw process, the cooking and forming operations can either be performed in a single TSE or one TSE is used for cooking and separate single screw low shear extruder could be used as a forming extruder.

(End of Article)

(The writer is C.E.O of M/s. Malik Engineers, Mumbai which manufactures wide range of single and twin screw extruders for Food, Plastics & Rubber industry)