Unit –IV

EXTRUSION BASED SNACKS

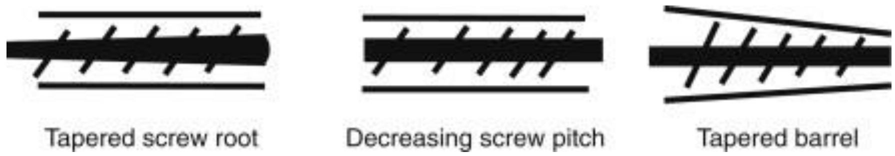
Single and Multiple die extruders

Structure
The basic structure of a single-screw extruder consists of the following elements

A hollow cylindrical enclosure, called the *barrel*. The barrel can be smooth or grooved. The flights of the rotating screw propel the material along a helicoidal channel (flow channel) formed between the screw root and the barrel. The width of the flow channel, resulting from the screw pitch, is considerably larger than its thickness. The gap between the screw tip and the barrel surface is made as narrow as possible

- A restricted passage element, known as the *die* at the exit end of the extruder. The functions of the die are to serve as a pressure release valve and to impart to the extrudate the desired shape, determined by the cross-section of the aperture(s). The die is sometimes preceded by a perforated plate (breaker plate) which helps distribute the compressed material evenly across the die
- A device for cutting the extrudate emerging from the die. In its simplest form this consists of a rotating knife
- Different kinds of devices for heating or cooling the barrel (steam or water jackets, electrical resistance heaters, induction heaters etc.). These elements, external to the barrel, are usually divided into individual segments, in order to impose different temperature conditions at different sections of the extruder
- A hopper for gravity feeding or an auger for positive feeding
- Ports for the injection of steam, water and other fluids as needed. Ports for pressure release
- Measurement instruments (feed rate, temperature, pressure) and controls
- A drive, usually with speed variation capability and torque control.
- Operation
- The materials processed in cooker-extruders are particulate moist solids or high viscosity dough-like fluids. As the screw rotates, the flights drag the material towards the exit. The flow channel, described above, is delimited by two solid surfaces, namely, the screw and the barrel. Friction with the moving material occurs on both surfaces. Ideally, the friction at the barrel surface should be the strongest of the two, in order for internal shear to occur. Were the friction weak at the barrel surface, e.g. as a result of lubrication, and strong at the screw surface, the material would stick to the screw and turn with it, without shear and without forward movement. Grooving helps reduce slippage at the barrel surface.
- Screw configuration is such that the flow area along the flow channel is progressively reduced. Consequently, the material is progressively compressed as it moves down the barrel. 'Compression ratio' is the ratio of the cross-section area of the flow channel at the feed end to that at the exit end. Reduction of the flow area can be achieved by several types of screw configurations. The most common are the progressively decreasing screw

pitch and the progressively increasing root (core) diameter . Screw configurations corresponding to compression ratios between 2 and 4 are common. The pressure developed in a cooking extruder can be in the order of a few MPa.



- Feed section: the main function of this section is to act as a screw conveyor, transporting the material from the feed entrance to the subsequent sections. Almost no compression or modification of the mass occurs in this section

- Transition section: this is the section where the material is compressed and heated

- Metering section: this is the section where most of the objectives of the extrusion process (melting, texturization, kneading, chemical reactions etc.) occur through shear and mixing.
- Through the friction, most of the power used for turning the screw shaft is dissipated into the material as heat. Thus, a portion of the heat delivered to the product is generated *in situ*. Additional heat is transferred from the externally heated barrel surface and supplied by direct injection of live steam. In single-screw extruders, the internally generated heat constitutes the major part of the energy input. Consequently, heating in a cooking extruder is extremely rapid.
- Because of the high pressure in the extruder, the moist material can be heated to temperatures well above 100°C (sometimes up to 180–200°C). When the pressure is suddenly released at the exit from the die, some of the water in the product is flash evaporated and, as a result, the product is puffed. The degree of *puffing* can be controlled by releasing some of the pressure and cooling the mass at the last section of the extruder, before the die. As a result of compression, a pressure gradient is built in opposite direction to the average movement of the mass. Therefore, the flow along the continuous flow channel contains two components: drag flow from the feed end to the die end, caused by the mechanical thrust of the screw flights, and pressure-driven back-flow in the opposite direction, caused by the pressure difference between the two extremities of the extruder. The net flow rate is the difference between the flow rates associated with the two velocity fields. Mixing in the single-screw extruder is, in great part, due to the existence of these two opposite flow patterns. The intensity of back-flow, and hence the 'pumping efficiency' of the extruder, depends on the resistance of the die and other restrictions placed on the flow path.

TWIN SCREW:

A twin- screw extruder has a pair of screws that are either intermeshing or non-intermeshing. The set of screws in the twin-screw extruder can be either co-rotating or counter-rotating. Co-rotating is more frequently used as it can impart more mechanical energy into the material than counter-rotating screws. The twin-screw extruder is more commonly used in the food industry because of its wide range of operating conditions and its ability to make wide range of food products, even though it requires a higher maintenance cost than a single-screw extruder

Twin-screw extruders have a wide flexibility for handling diverse ingredients and a higher production rate than single-screw extruders. Twin-screw extruders can be operated with a greater range of moisture content, which is a drawback for a single-screw extruder. The preconditioning systems can be used to expand the capabilities of both single- and twin-screw extruders. The twin-screw extruder has a higher efficiency in mixing, a self-wiping capability that can prevent residues from accumulating, and a heat transfer that is relatively faster and more uniform from the barrel to the ingredients