Department of Water and Sewage Management and Waste Technology

Recycling

LABORATORY 3

Topic: EXTRUSION AND MELT FLOW RATE (MFR) - PROCESSING

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1. Extrusion

Extrusion is a continuous process of shaping products from plastics, known as profiles, which are long objects with a constant cross-section, such as pipes, rods, sheets, and films. The extrusion process involves continuously plasticizing the material in the plasticizing system of the extruder and then pushing (extruding) this plasticized material under pressure generated in the plasticizing system through the forming tool openings called a die. Plasticization occurs as a result of heating the material by the extruder's heating system and due to energy dissipation in the extruded material. Extrusion is carried out on a production line consisting of an extruder and die, a calibrating and cooling device, and receiving, cutting, and stacking (or winding) devices. Extrusion can be used in the processing of thermoplastic and elastomeric materials. The schematic of a classic single-screw extruder is shown in Figure 1 and Figure 2 presents a schematic of an extrusion die, in this case, for pipe extrusion. Figure 3 shows a sample schematic of a technological extrusion line.

The extruder consists of the following components:

- drive system (motor, gearbox)
- plasticizing system (hopper, barrel, screw, heaters, and fans)
- control and regulation system (power, temperature, etc.).

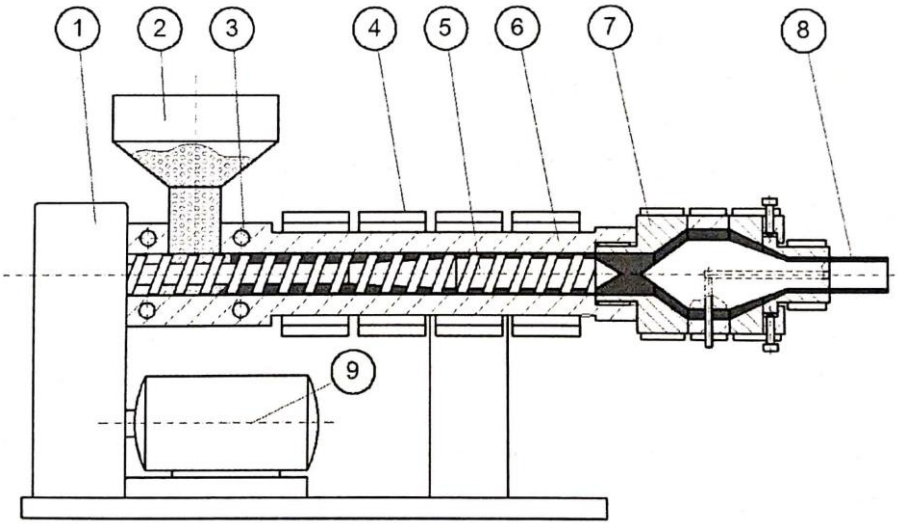

Figure 1. Schematic of a single-screw extruder; 1 – gearbox, 2 – hopper, 3 – cooling system for the feed zone, 4 – heating and cooling system, 5 – screw, 6 – barrel, 7 – die, 8 – extruded product (pipe), 9 – drive motor [2].

The plasticizing system, the core of the extruder, performs the following functions:

- transporting the material from the hopper to the die via the rotational movement of the screw,
- heating and plasticizing the processed material,
- compressing the material to generate the pressure necessary for extrusion through the die,
- mixing to homogenize the composition, properties (thermal and mechanical), and material structure.

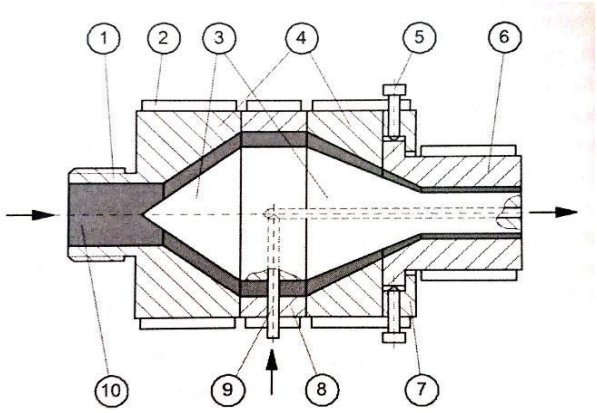

Figure 2. Schematic of an extrusion die for pipe extrusion; 1 – die mounting tip, 2 – heaters, 3 – core, 4 – casing, 5 – centering screw, 6 – forming ring (die nozzle), 7 – centering ring, 8 – core support, 9 – compressed air, 10 – die channel [2].

Heating the material during the extrusion process occurs through heat supplied to the processed material by the heaters and heat generated in the material due to energy dissipation. However, there are also designs for extruders without heaters (so-called autotermal extruders), where all the heat required for plasticization is generated solely by energy dissipation.

To summarize, depending on the design, extruders can perform five basic functions:

- transporting material from the hopper to the die (typically a screw transport system),
- plasticizing the material to make it formable,
- generating the pressure needed to extrude the material through the die,
- mixing the material to homogenize its thermal and mechanical properties,
- shaping the product in the extrusion die.

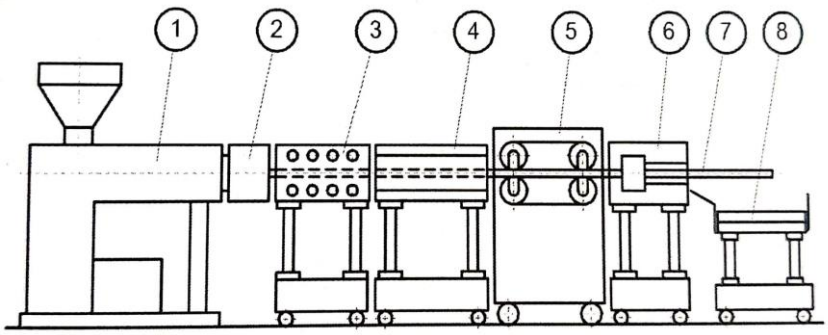

Figure 3. Schematic of a technological line for pipe extrusion; 1 – extruder, 2 – die, 3 – calibrating device, 4 – cooling device, 5 – receiving device, 6 – cutting device, 7 – extruded product, 8 – stacking device [3].

In plastics processing, extrusion serves one or both of the following functions: homogenizing and/or forming.

2. Recycling line

A laboratory recycling line includes:

- extruder,
- belt puller,
- dryer,
- granulator.

The puller is equipped with cooling by cold air to cool the rod obtained from the extruder below the softening point of the material. The material is then fed into the granulator, which is a milling machine with adjustable rotational speed, from where it is collected into a container. If faster cooling is needed for the extruded material, the belt puller can be replaced with a water-filled tank. In such cases, a dryer is required before feeding the material into the milling machine.

3. Melt Flow Rate (MFR)

The Melt Flow Rate (MFR) is a value expressing the mass of molten material that flows through a nozzle of specified shape and dimensions within a given time under a defined load and temperature. The MFR value depends on molecular weight, degree of polymerization, branching of macromolecules, and the presence of additives. The MFI is used for thermoplastic materials and is denoted by the symbol MFR.

$$\boldsymbol{MFR = \frac{g}{10\ min}}$$

where: g – mass of the material.

Figure 4. Ceast Melt Flow Junior

4. References:

[1] Wilczyński K., et al.: "Polymer Processing," OWPW, Warsaw, 2018
[2] Wilczyński K., et al.: "Plastics Processing," OWPW, Warsaw, 2000
[3] Wilczyński K., et al.: "Selected Issues in Plastics Processing. Laboratory," OWPW, Warsaw, 2013