The use of graphite as a filler will make it possible to obtain new composite materials and mixtures with improved operational characteristics (strength, stiffness, heat resistance, etc.) for 3D printing.

UDC 678.05 Energy and resource saving technologies and equipment

DEPENDENCE OF THE FORM OF THE 3D PRINTER EXTRUDER SCREW FROM THE PROPERTIES OF THE POLYMER MATERIAL

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One of the main methods of polymer processing is extrusion. Extrusion (from Late Latin extrusio - pushing out) is a technology for obtaining products by forcing a viscous molten material through a forming hole [1].

Screw extrusion is a continuous process in which there is a constant phase transformation of thermoplastic polymer material, starting from granules (crushed particles) of thermoplastic polymer to a viscous polymer melt. The main element is the screw (worm) of the extruder, which feeds the granules along the material cylinder. The polymer particles are then melted using external heaters and extruded from a nozzle attached to the material cylinder.

Extrusion processes are widely used in industries that seek to implement advanced solutions in the manufacture of finished products in the chemical, food, and pharmaceutical sectors. Films and sheets, pipes, hoses and profiled products of various cross-sections are produced by the extrusion method, thin-layer coatings are applied to paper, cardboard, fabrics, metal foil, metal wires and cables are covered with plastic insulation. The method is characterized by high productivity and continuity. Thanks to this, conditions arise for the automation of not only individual equipment, but also entire productions. In this regard, extruders are one of the most promising types of equipment for processing polymer materials.

Screw Extrusion Additive Manufacturing (SEAM) is a universal process of deposition of polymer material for 3D printing.

Nowadays, technologies of additive three-dimensional prototyping are constantly developing. One of the most popular 3D printing technologies is the FFF - Fused filament fabrication technology. [2]. A polymer thread with a diameter of 1.75 or 2.85 mm is used as a material for printers that work according to this technology. The cost of filament can be quite significant compared to the raw material from which it is made. Therefore, the direction of development for 3D printers of screw extruders, which use granulated thermoplastic polymers or crushed waste particles as material, is promising and relevant. Today, industrial enterprises do not manufacture screw extruders for 3D printers. There are several projects using screw extrusion in 3D printers. Therefore, the screws are not optimized for 3D printing conditions.

Screw extruders are divided into single-screw and multi-screw. A single-screw extruder is the most common type of equipment used in polymer processing enterprises. Its main advantages are: simple design, relatively low cost, strength and reliability, as well as a favorable ratio of performance and cost.

The screw of a conventional extruder for plasticizing the material has three geometrically different zones (Fig. 1).

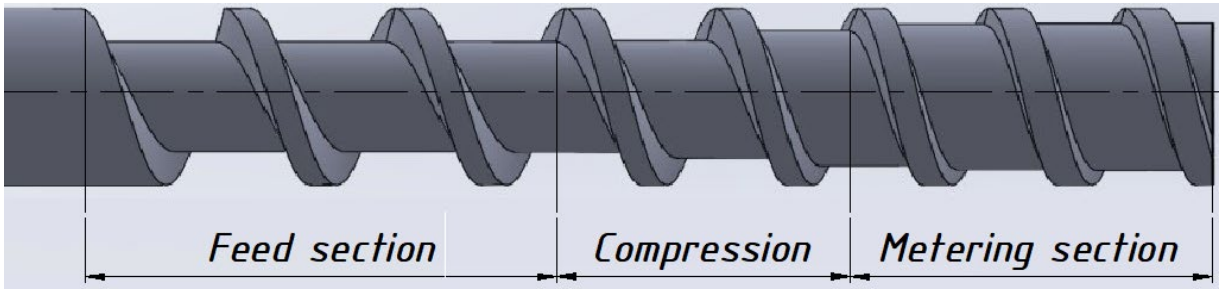

Fig. 1. The geometry of the screw of a conventional extruder

For a single-screw extruder, the main process parameters that determine the amount of molten polymer flow are: screw geometry, change in melt temperature, and screw rotation speed. These process parameters will also determine parameters such as torque and power consumed by the device.

In work [3], depending on the type of polymer materials being processed, screws are divided into 3 main groups:

- screws for polymers with a wide temperature range of plasticization (softening). Such augers have a slightly longer loading zone length compared to the compression and dosing zones. The lengths of the compression and dosing zones should be approximately the same. With different extrusion modes, it is extremely difficult to meet this requirement due to the fact that the length of the dosing zone strongly depends on the technological modes of processing certain types of polymer materials, and it is economically unprofitable to manufacture screws for each mode. This type of auger should ensure the degree of compression of the material and i_{dc} = 2.0-3.5;

- screws for materials with a wide range of softening temperatures and low thermal stability. The length of the material loading zone for them is similar to the screws of the previous group. The compression zone is slightly larger. There is no dosing zone in most cases. The degree of compression of the material is recommended and i_{dc} = 1.5-2;

- screws for highly crystalline materials. Such augers have an increased loading area compared to the loading area of the augers of the first group, a reduced compression area and a similar dosing area. They are characterized by the maximum degree of compression of the material and i_{dc} = 3-4.5.

Due to the fact that most polymer materials (PLA, ABS, PS, PC, etc.) used in 3D printing have a wide temperature range of plasticization, and crystalline plastics (PLA, PA, PE, PP, etc.) are not highly crystalline, the screw design of the first group was chosen for the 3D printer extruder [4].

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УДК 621.311.11 Енерго-і ресурсозберігаючі технології та обладнання