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MODERNIZATION OF THE EXTRUDER WORM WITH THE PURPOSE OF IMPROVING THE EFFICIENCY OF MATERIAL MIXING IN THE MANUFACTURE OF POLYMER PRODUCTS

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ABSTRACT

The study selected a technical solution to improve the mixing of polymeric materials in the extruder with the modernization of the worm based on the execution of a detachable mixing and dispersing section. It is formed by a pair of elements, each in the form of a cylinder with coots evenly made along the side surface inclined towards one of its bases, converging to nothing. This design of the extruder worm eliminates the formation of stagnant zones, but also due to the alternation in the circular direction of each element of the specified section of the annular sections and sections in the form of circular segments, it provides a high mixing and dispersing effect of the machine as a whole.

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Introduction.

In the field of production and processing of thermoplastic polymeric and composite materials, this type of technological equipment as an extruder is used. An extruder (extrusion press) is a machine for forming plastic materials, by giving them various outlines, by pushing (extrusion) through a profiling device — an extrusion head [1].

The extrusion process consists of the melting of polymeric raw materials and the continuous pushing of the viscous material through the extrusion head, which forms the profile of the future product. The cross-section of the head profile coincides with the cross-section of the finished production [2].

This usually happens in order to get:

- different types of pipes;
- plastic panels;
- Film;
- cable and wire.

The extruder can use various types of polymers in its work, even polyethylene, polyvinyl chloride, etc. p. Nowadays, the principle of operation of the extruder is applied even to bioplastics. This device can be used to produce the technological process. As a result, parts can be obtained using the method of pushing the alloy through a special tool that gives shape. During extrusion, a large number of factors affect the raw materials: elevated temperatures, and mechanical loads.

The advantages of extruders include simple design and good plasticization, low energy consumption, low noise, uninterrupted operation, and high bearing capacity. The disadvantages of extruders are insufficient high-quality mixing of the supplied polymer material, unlike the two-worm extruder design [3].

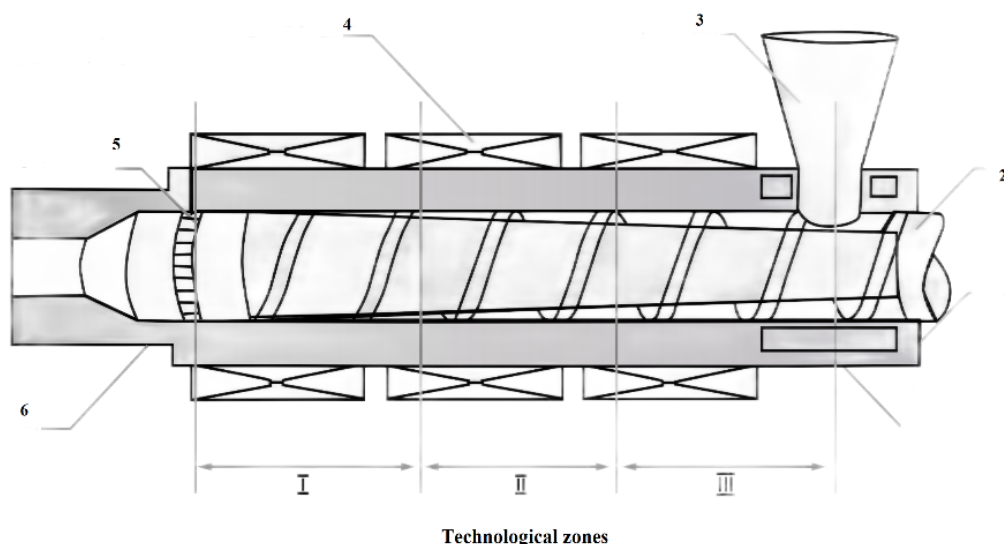
The main disadvantage of a single-screw extruder is that it is not always possible to use it. For example, if powder semi-finished products act as the initial raw materials, then the presence of one screw in the equipment does not allow to cope with the mixing of the mass in the process of its melting and subsequent homogenization [4].

The purpose of the article is to choose a way to improve the mixing of polymeric materials in a single-worm extruder based on the modernization of the worm.

On the sobriety of the design and the principles in the action of a single-worm extruder for the production of polymer products

For the production of products by extrusion, thermoplastics, reactoplasts, elastomers and fluoroplastics are used. The type of polymeric material depends on the type of extruder and the type of product.

For an extruder of any type, the following working units are characteristic: a material cylinder (machine body); the working body of the unit (auger, piston, disk); loading node; adjustable AC motor; heating and cooling systems; forming head; regulating and control-measuring devices (Fig.1) [2].



*Fig. 1. Design of single-worm extruder:
1 material cylinder (machine body); 2 working body of the unit (auger, piston, disk); 3 loading node; 4 – heater; 5 – grid with grids; 6 forming head and technological zones (III loading zone; II zone of plasticization; I dosing zone)*

The body has several longitudinal channels that prevent the rotation of the polymer material during the movement of the auger. This helps to improve the quality of melt homogenization inside the cylinder. Additionally, for this, augers are equipped with teeth, faces, cams.

The main criterion for classification is the working body installed in the machine. This can be an auger (worm/screw), a piston, or discs. On this basis, extruders are divided into: auger; disk; piston.

Screw extruders are additionally classified according to the following parameters:

- the number of augers (single-screw, double-screw and multi-screw);
- arrangement of augers (parallel, conical);
- direction of rotation (anti-directional, directional) [2].

Let us consider in more detail in the article non-cavi extruders. Screw units work on the principle of a meat grinder. The main working space is a material cylinder, conditionally divided into 3 technological zones: III- of the loading; II- of plasticization; I- of this dosage

In the loading area, the composite material is fed through the hopper as granules or powder. It can be a homogeneous composite or a mixture of primary and secondary raw materials, dyes. Secondary (processed) raw materials can reduce the cost of production, adjust the physical and mechanical properties of the finished product. In the dosing zone, the polymeric material changes the state of aggregation – it acquires a viscous consistency. In some models, the loading chamber may have a closed design with installed sensors for accurate dosing of components and control of temperature and humidity of raw materials.

The auger installed inside the material cylinder is driven by the engine. When rotating, it captures the material and pushes through the nozzle of the extrusion head. The pressure level of the worm extruder is 15-100 MPa. In the process of moving through the cylinder as the screw rotates, the feedstock is compacted and mixed.

In the plasticization zone, the material changes the structure. Under the action of the pressure created by the auger and additional heating from the external heaters, the polymerization and melting process starts.

A completely homogeneous mass under pressure is pushed through the forming head in the dosing zone. The shape and size of the future product is set by the calibration device. Cylinder temperature control is carried out using heaters (heating) and cooling water channels (cooling). For the processing of hygroscopic polymers of the extruder design, a degassing zone is additionally provided.

The simplest design is a single-worm extruder, in which only one auger is installed. This type of equipment is the most affordable. It moves easily if one needs to move the production line to another location. The design of the unit is simple, one operator is enough to control the technological process [2].

The main working bodies of a single-worm extruder are the cylinder and the worm rotating in it. The main process that takes place in all extruders is the transportation of material along the working bodies, which in worm extruders are a rotating worm (auger) and a fixed cylinder. Simultaneously with the transportation in the screw cutting channel, a variety of processes take place: heating the material due to the deformation energy is converted into heat, as well as due to the heat coming from the cylinder equipped with heaters, pressure generation, compaction and monolithization of granular or granular components of the processed raw materials, chemical and phase transformations caused by heating and pressure, removal of one or more components (liquids, gas), etc. Due to this variety of processes, worm extruders are used in many technological schemes for the production and processing of polymers and plastics.

When using an extruder for polymer and plastic products, the auger blade captures raw materials in the loading area. Next, it moves sequentially along the entire length of the

cylinder of the housing, starting from the heating zone through the homogenization and molding section. Depending on the features of the technological map that the equipment has, as well as the type of raw materials used for the production of products. At the same time, augers can provide several options for execution - conical, cylindrical and normal high-speed. Augers that taper to the outlet can also be used. For this equipment, as the main parameter, experts consider the ratio of the working diameter of the auger and its length. Augers also differ in the step of the turns and their depths and [5]. Therefore, to modernize the single-screw extruder, it was decided to modernize the worm as one of the most important elements, the design of which most affects the mixing efficiency of the polymer material used.

Materials and research methods on the choice of variant modernization of the worm one auger extruder for the production of polymeric products

In order to improve the efficiency of mixing the polymer material in the extruder for better manufacturing of polymer pipes, a literary-patent search was conducted for choosing the option of upgrading the single-screw extruder worm. As a result of the literary-patent search and analysis of options for improving the design of a single-worm extruder, several interesting technical solutions were found for the modernization of the extruder worm. Let us consider them in more detail for choosing the most appropriate technical solution for improving the mixing of processing polymeric raw materials.

The source [6] proposes the design of an extruder for the processing of high-molecular compounds and materials based on them, containing a hollow shaft equipped with screw cutting, which is distinguished by the fact that a channel connected to the shaft cavity is made in the cutting crest. Performing in the ridges of cutting a sofa connected to the shaft cavity ensures that the coolant is supplied directly to the inter-turn space of the worm. This ensures minimal thermal resistance to the heat transfer process between the coolant and the processed material. This design of the extruder worm, simple in manufacture and operation, will significantly improve the working conditions of worm extruders, but will not solve the problem of improving the mixing of polymeric material.

The source [7] considers an extruder for processing materials using high-molecular compounds, containing a housing with loading and unloading holes, as well as placed in it with the possibility of rotation by a worm. The worm has a removable mixing and dispersing section fixed on its core, the base of which is round on the side of the unloading hole of the case, and the base on the side of the loading hole of the case is convex with a shape different from round. Due to the variable along the worm axis of the size of the working channel, this machine somewhat intensifies the processing process. But such a design of the base of the mixing and dispersing section on the side of the loading hole of the housing convex with a shape different from the round one contributes to the formation of stagnant zones in the place of the specified base. This leads to mechanodestruction of the processed material, especially heat-sensitive, and therefore reduces the quality of the products [7].

We offer to choose a technical solution based on a prototype worm with a removable mixing and dispersing section [8]. The executed drawing to the construction and modernized worm of the extruder with the mixing and dispersing section consists of: tip 1, pairs and elements in the form of a pair of bushings 2 and 3, worm 4 and presented on Fig.2. Fig. 2, A-A shows a cross-section at the junction of two paired bushings with cobbles of the modernized mixing and dispersing zone of the worm. Fig. 2, C shows the tip of the modernized worm on a larger scale. Figure 2, B-B shows an inverted cross-section of a coil of a modernized worm on an enlarged scale.

This technical solution is that the mixing and dispersing section of worm 4 is formed by at least one pair of elements 2 and 3, each of which is made in the form of a cylinder with coots evenly made along the side surface inclined towards one of its bases, converging to

nothing, forming in each element one round base and the second base in the form of a regular polygon with straight or rounded vertices, At the same time, the corresponding bases of each pair of elements are made the same, and the elements of each pair are in contact with each other with the same bases [8].

The material to be recycled enters the loading hole of the housing extruder, where it is captured by cutting worm 4 and then transported by it towards the unloading hole of the machine. At the site of the mixing and dispersing section of a pair of bushings with coots 2, 3, intensive mixing and dispersion of the processed material is carried out (Fig. 2).

The proposed design of the modernized worm single-worm extruder, simple in manufacture and operation. It also significantly increases the efficiency of processing polymers, plastics and rubber compounds of a wide range, since the mixing and dispersing section of a pair of bushings with coots 2 and 3 of worm 4 can be made of quick-release and variable geometry. This significantly expands the technological capabilities of the extruder as a whole [8].

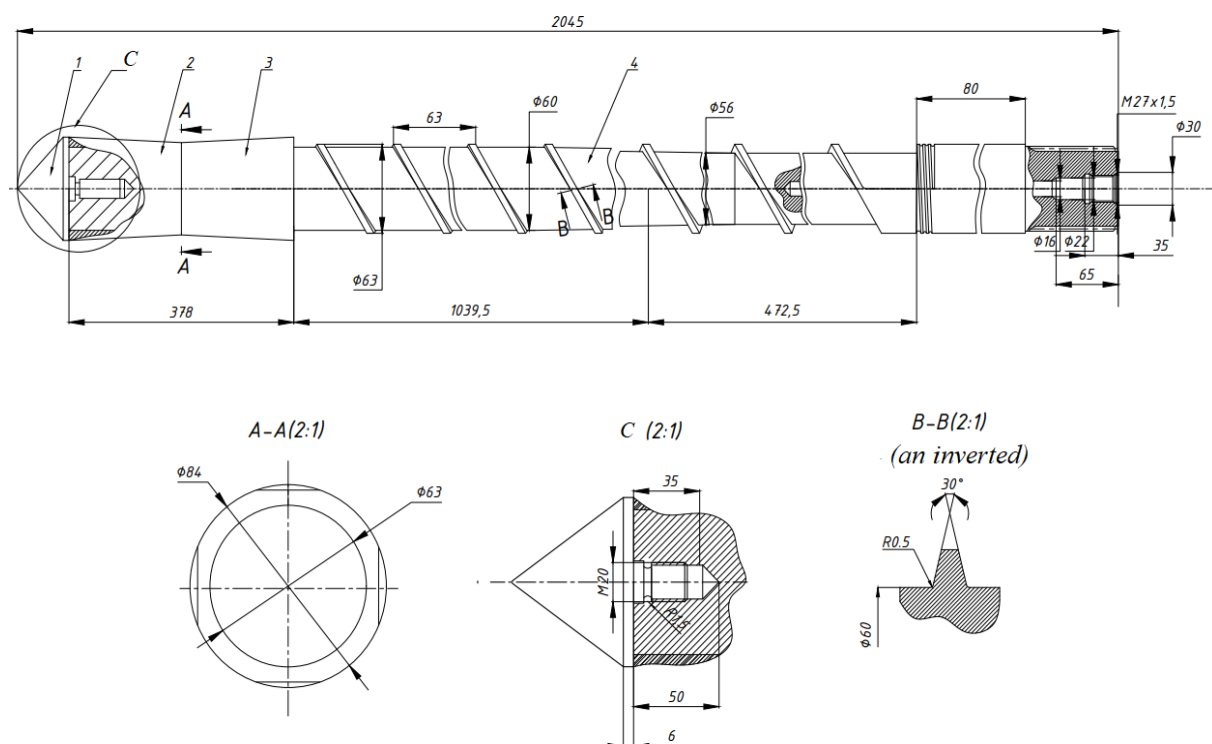


Fig. 2. Modernization design of single-worm extruder:
1- tip; 2, 3 - pair of elements in the form of bushings; 4- worm

Conclusions.

Thus, the technical result of the proposed design for the modernization of the extruder worm is that not only the smooth flow of the melt of the processed material along the mixing and dispersing section of the worm is ensured, which eliminates the formation of stagnant zones. Also due to the alternation in the circular direction of each element of the specified section of the sections of the ring shape and sections in the form of circular segments, a high mixing and dispersing effect of the machine as a whole is ensured. It should be noted that according to the prototype [8] there is the possibility of performing elements of the mixing and dispersing section of different lengths, which will contribute to increasing the efficiency of mixing and processing of polymeric materials. Therefore, the proposed modernization of the worm will improve the quality of the manufactured products extruder.

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