INVESTIGATION OF TECHNOLOGICAL PARAMETERS FOR 316L STEEL SAMPLES OBTAINED USING EXTRUSION ADDITIVE MANUFACTURING TECHNOLOGY*

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Additive manufacturing (AM) is a process based on creating a physical object from a 3D model by layer wise material addition. The first AM systems worked mainly with polymeric materials, but today the range of materials used has increased significantly (composite materials with various types of metals and ceramics). Currently, many different AM technologies have been developed, but one of the most promising is material extrusion AM.

There are a number of empirical approaches to determining optimal extrusion printing parameters. Basically, the parameters are set in specialized software - a slicer. In this work, we used the most modern slicer to date - Orcaslicer, which allows for a series of calibration printing sessions to identify and optimize printing parameters [1]. The work considered a material for extrusion printing based on 316L steel [2,3].

Briefly, the procedure for selecting the optimal parameters used in the work can be described as follows: first, the printing temperature is selected, since it depends on the polymer binder used. Then the extrusion coefficient is selected, that is, the extrusion value at which the diameter of the extruded line will coincide with the diameter specified in the slicer. And the last thing that is regulated is the flow, that is, the volumetric printing speed. The flow includes the speed of head movement, extrusion speed, extrusion width, as well as other parameters responsible for print quality.

If the temperature and extrusion ratio are selected correctly, then the optimal volumetric flow of material can be calculated with sufficient accuracy. The selection of the correct temperature was carried out during the feedstock development phase in the first year of the project. The optimal operating temperature is determined by the properties of the polymer binder. The operating temperature and the maximum temperature of the polymer binder are determined by the manufacturer. In our case, when determining the MFI, a temperature of 150 °C was used. During printing experiments, this temperature also proved to be optimal.

The extrusion coefficient is calculated on samples that are automatically generated in OrcaSlicer. Samples are rectangular plates in which the extrusion coefficient changes. It is necessary to select an extrusion coefficient at which there are no internal macrodefects and compliance with the external geometry of the part is achieved (there is no significant overextrusion).It was found that with a coefficient value of 1.43, the most dense structure in the cross section is formed. A further increase in extrusion leads to a significant sagging of the side faces, as well as to a deterioration in the quality of the upper surface of the samples.

To determine the optimal flow, the standard OrcaSlicer test was used, which involved printing a calibration part in which the volumetric flow of material was varied at each layer. When preparing the test, the initial flow f0, the final flow f1, and the step along the flow Δf are specified. After printing, the smoothest layer is visually found, in which there are no printing defects, in particular underextrusion or overextrusion.

The height h from the substrate to the layer in millimeters is calculated and the optimal flow f is calculated using the formula $f = f_0 + h\Delta f$. To calibrate the flow, the parameters $f_0 = 1$ mm^3/s, $f_1 = 10$ mm^3/s, $\Delta f = 0.25$ mm3/s were used. The test showed that the skips begin at a height of 18 mm, which gives a flow value of $f = 5.5$ mm^3/s. A 10% flux margin was used in the work, so a flux of $f = 5.0$ mm^3/s was used.

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