POLITECHNIKA ŚLĄSKA W GLIWICACH

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PRACA DOKTORSKA

Nowe metody poprawy więzi międzywarstwowej w produktach z tworzyw i kompozytów polimerowych wytwarzanych technologią drukowania 3D FDM

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Abstract

The aim of this doctoral thesis is to develop new methods to improve interlayer bonding in products made from polymers and polymer composites manufactured using Fused Deposition Modeling (FDM) 3D printing technology. A comprehensive literature review was conducted on 3D printing technologies, with particular emphasis on methods for enhancing interlayer bonding in FDM. Theories of adhesion and surface modification techniques, such as plasma and chemical modifications, as well as the application of adhesive agents and nanoparticles, were discussed. Additionally, the impact of optimizing printing process parameters, such as nozzle temperature and printing speed, on improving interlayer adhesion was presented.

In the course of the research, prototypes of new FDM 3D printers were developed and constructed, utilizing innovative methods to enhance interlayer bonding. Four technological concepts were designed and built to improve interlayer bonding in printed parts: a 3D printer with laser heating, which implements additional layer heating using a laser beam; a 3D printer with a rotating head, enabling mechanical increase of the contact surface between layers through rotational movements of the head; a 3D printer combining a rotating head with laser heating, integrating the benefits of both previous methods to enhance interlayer bonding; and a 3D printer with an upper heating plate, which, by controlling the temperature of the surrounding environment of the printed object, minimizes material shrinkage and improves interlayer bonding.

Verification studies of the proposed solutions were conducted, analyzing the impact of the applied methods on the mechanical properties of the printed elements. The study results demonstrated that the application of innovative methods in conjunction with the optimization of printing process parameters leads to a significant improvement in interlayer bonding, resulting in increased strength and enhanced durability of the printed parts.

After conducting preliminary studies and evaluating the effectiveness of the proposed technologies, a 3D printer with an upper heating plate was selected for the main phase of the research. This choice was driven by the potential of this technology to process the most advanced materials, particularly polyether ether ketone (PEEK) filled with ground carbon fiber. PEEK CF, used in medicine and aerospace, although a thermoplastic with exceptional mechanical, thermal, and chemical properties, poses high technological demands in FDM printing.

The research results demonstrated that the application of an upper heating plate significantly improved the bonding between layers in printed PEEK composites. An increase in bending strength was observed in comparison to samples printed without additional heating.

The conducted studies confirm that the integration of innovative technological solutions with the optimization of printing process parameters allows for a significant improvement in interlayer bonding in products manufactured using the FDM method.