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СИСТЕМИ РОЗРОБЛЕННЯ ТА ПОСТАНОВЛЕННЯ ПРОДУКЦІЇ НА ВИРОБНИЦТВО. ІНДУСТРІЯ 4.0. СУЧАСНИЙ НАПРЯМОК АВТОМАТИЗАЦІЇ ТА ОБМІНУ ДАНИМИ У ВИРОБНИЧИХ ТЕХНОЛОГІЯХ

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IMPLEMENTATION OF ADDITIVE TECHNOLOGIES FOR THE COMPLEX DEVELOPMENT OF BUILDINGS AND STRUCTURES BY MEANS OF 3D PRINTING

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An uninterrupted movement towards the implementation of the basic principles of the 4th industrial revolution, well-known as “Industry 4.0” [1], requires an application of 3D printing to create buildings and structures that fundamentally changes our traditional viewpoint.

3D printing technology has appeared due to the development of digital technologies in the field of the design, simulation, calculations and mechanical processing and has acquired an explosive nature. Modern 3D printing technology as additive one is widely used in the field of material production. It represents the process of building physical objects (parts) by means of layer-by-layer deposition. In this case all stages of the project from the idea to realization are in the same technological line, and all the operations are implemented in a digital form. This means a real transition to paperless technologies, when manufacturing parts do not need to create the traditional drawing documentation.

Additive technologies permanently cover new areas of human activities, one of which is the creation of buildings and architectural structures by means of 3D printing [2]. These technologies allow building new areas in record time by creating streets and districts in a few months. The process requires significantly less financial costs unlike traditional techniques and occurs with using modern materials, such as fast hardening concrete, as well as due to conditions of the significant waste reduction, intensification of the manufacturing process, individualization of the product, accelerating the implementation of brand-new ideas, possibility of processing the parts of ultra-high complexity with relative easiness of personnel training. It essentially accelerates the building process and allows creating enough strong and reliable designs [3, 4]. Some models of 3D printers are capable to build not only concrete designs, but also to lay all the necessary communications (electrical wiring, pipeline, gas equipment, etc.). This technology can be applied for the creation of budget buildings or designs in the areas of natural disasters in a short time without using a large number of workforces.

The building principle is very simple [5–7]: the specially prepared viscous concrete mixture is filled into 3D printer, and then layer-by-layer deposition is realized due to the extrusion. Lower layers of concrete are compressed, which gives the strength of created designs. Workers only insert the metal rebar between walls for reinforcing concrete bars. This technology significantly reduces building terms and cheapens the process. One of the advantages is the possibility of partial using the industrial waste as a construction material.

Using 3D printing for building involves a wide range of problems, which are located in different fields, such as technologies of building materials, equipment and software, the solution of which allow to take a leading position in the global construction industry [6]. Despite the fact that the construction industry is conservative behind of terms for using 3D printing in another industries, the elimination of conventional concepts in the construction field is occurred in the global real estate market and construction services, as well as advanced directions are focused precisely on additive technologies. Thus, the available space in the market of building 3D printing progressively occupy such innovative companies as Winsan (China), which is represented “Office of the future” (2016, Dubai, UAE), Total Kustom (USA), which realized the project “Lewis Grand Hotel” (Philippines), as well as Specavia (Russian Federation), Monolite (UK), DUS architectural company, and WASP with the project of environmentally friendly village with low energy consumptions [8]. As a result, building additive technologies can be classified as green technologies due to the almost waste-free production [9].

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