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Eureka Journal of Education & Learning Technologies (EJELT)

ISSN 2760-4918 (Online) Volume 2, Issue 11, November 2026
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APPLICATION OF ADDITIVE MANUFACTURING TECHNOLOGIES IN THE DEVELOPMENT OF CASTING PATTERNS FOR MACHINE COMPONENTS

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Abstract

The article discusses the possibilities of applying additive manufacturing technologies in the production of casting patterns for machine components. The specific features and technological limitations of conventional pattern-making methods are considered, together with the role of FDM (Fused Deposition Modeling) technology in foundry applications. Particular attention is paid to the preparation of casting patterns from PLA polymer material, digital modeling, geometric parameter definition, and the relationship between these processes and 3D printing. The practical application of additive manufacturing is illustrated using a crusher wear plate pattern produced from PLA material.

Keywords: Additive manufacturing, 3D printing, FDM, PLA, foundry, casting pattern, SolidWorks, mechanical engineering, crusher wear plate.

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Introduction

In modern mechanical engineering, the application of efficient and economically viable technologies for manufacturing components with complex geometric shapes is of considerable importance. In particular, the preparation of casting patterns in foundry production directly affects the geometric accuracy of cast components, surface quality, and manufacturing time.

Conventional casting patterns are mainly manufactured from wood, metal, and other structural materials through machining processes. The production of complex-shaped patterns using these methods may require considerable time, labor, specialized equipment, and skilled personnel.

In recent years, the development of additive manufacturing technologies has introduced new opportunities for pattern-making processes. These technologies are based on the layer-by-layer formation of objects using digital three-dimensional models and make it possible to manufacture components with complex geometric configurations. The application of additive manufacturing in foundry production enables the integration of digital design, pattern fabrication, and manufacturing processes. This approach is particularly relevant for wear-resistant components, crusher plates, and other machine parts with complex geometries.

The purpose of this article is to analyze the possibilities of applying additive manufacturing technologies in the production of casting patterns and to discuss their practical application using an FDM-produced PLA pattern as an example.

LITERATURE REVIEW AND METHODOLOGY

The development of additive manufacturing technologies has significantly expanded the possibilities of producing casting patterns for mechanical engineering components. Traditional pattern-making methods, mainly based on wood and metal processing, require machining operations, specialized equipment, and considerable labor input. These limitations have encouraged

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researchers to investigate alternative approaches based on digital design and 3D printing technologies.

Royan et al. [1] investigated the application of FDM 3D printing for producing patterns used in sand casting. Their research demonstrated the potential of polymer-based additive manufacturing for foundry applications. Bernat and Kroma [2] analyzed the use of fused filament fabrication and fused deposition modeling in casting pattern production, emphasizing the importance of printing parameters and material selection. Oguntuyi et al. [3] reviewed the influence of molding sand properties on the quality of components manufactured through additive manufacturing-based sand casting. Patil et al. [4] examined the development of pattern less rapid sand casting and the integration of digital technologies into foundry production. The general principles and technological characteristics of additive manufacturing are also discussed in the works of Gibson et al. [5] and Gebhardt [6].

The analysis of these publications indicates that FDM technology is a promising method for manufacturing polymer casting patterns. Its application makes it possible to produce complex geometric configurations directly from digital models, reduce dependence on conventional machining operations, and simplify modifications to pattern design. However, effective implementation requires consideration of material properties, geometric accuracy, printing parameters, dimensional allowances, and subsequent foundry operations.

The methodological approach adopted in this article is based on the analysis of scientific publications, examination of additive manufacturing processes, and consideration of a practical example involving a crusher wear plate pattern.

At the initial stage, the geometry of the crusher wear plate was studied and its three-dimensional digital model was developed using SolidWorks software. The model was prepared according to the structural configuration of the original component, including its working surface, ribs, and mounting openings. After

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completing the digital design, the model was converted into STL format and prepared for 3D printing using slicing software.

The physical pattern was manufactured using FDM technology and PLA polymer filament. The manufacturing process involved layer-by-layer deposition of heated polymer material according to the geometric information contained in the digital model.

The main technological parameters included a model scale of 1:3, an infill density of 25%, five perimeter walls, and a dimensional allowance of 3%. The printing process required approximately 24 hours and consumed about 1100 g of PLA material.



Figure 1. Crusher wear plate pattern manufactured from PLA polymer using FDM technology.

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The methodology also considers the relationship between the manufactured polymer pattern and the resulting metal casting. Particular attention is paid to the correspondence of their geometric configurations, reproduction of structural elements, and suitability of the pattern for subsequent foundry operations.

Thus, the approach combines a review of scientific literature with the consideration of a practical technological example, providing a basis for discussing the application of additive manufacturing in the production of casting patterns for complex machine components.

4. Discussion

When evaluating the application of additive manufacturing in foundry production, the geometric and structural correspondence between the manufactured pattern and the resulting cast component is particularly important.

For components such as crusher wear plates, which operate under conditions of mechanical wear, the working surface, ribs, openings, and other structural elements must be accurately reproduced in the pattern.

A pattern manufactured from PLA material can serve as a technological basis for preparing a casting mold. In this process, the external surface, geometric configuration, and interaction with the molding materials should be considered.

The quality of the mold, properties of the molding mixture, and metal pouring conditions also play an important role in the casting process. Therefore, the application of additive-manufactured patterns should be considered as part of the entire foundry process rather than only in terms of 3D printing parameters.

The appearance of the PLA pattern and the corresponding cast metal component is presented in Figure 2

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Figure 2. External appearance of the cast metal crusher wear plate.

The presented image illustrates the structural configuration of the cast component. Such a comparison provides a visual basis for examining the geometric features of the pattern and considering its application in the foundry process.

Another important aspect of additive manufacturing is the integration of digital design and physical production. This approach makes it possible to modify the component design and introduce technological improvements at the digital modeling stage.

The use of additive manufacturing technologies can therefore contribute to the development of more flexible pattern-making processes, particularly for machine components with complex geometries.

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5. Conclusion

The application of additive manufacturing technologies in casting pattern production represents a promising direction in modern mechanical engineering.The use of PLA material and FDM technology provides opportunities for manufacturing patterns with complex geometric configurations through digital design and layer-by-layer fabrication.

The development of a three-dimensional model in SolidWorks and its conversion into STL format establish a technological connection between digital modeling and physical pattern production

The crusher wear plate example demonstrates the practical possibilities of applying additive manufacturing in foundry pattern making.

In this process, geometric accuracy, material properties, printing parameters, and casting technology should be considered together.

Thus, additive manufacturing technologies create important opportunities for digitalizing casting pattern production, modifying component designs, and manufacturing patterns for complex machine components.

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