Transactions on Additive Manufacturing Meets Medicine
Trans. AMMM, 2026, Vol. 8, No 1, Suppl. 1, Article ID 2766, 1 Page

Infinite Science Publishing

Abstract

Pneumatically assisted gerotor pump system for high-volume bioprinting of viscous hydrogels

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High-volume bioprinting applications, such as the fabrication of large tissue constructs or organ models, demand extrusion systems capable of delivering highly viscous bioinks at consistent flow rates over extended periods [1]. While conventional pneumatic or piston-driven systems are commonly employed, they exhibit limitations regarding precise flow control and scalability. Gerotor pumps, characterized by their positive displacement mechanism, offer an attractive alternative due to their precise volumetric output directly governed by rotational speed, enabling accurate and reproducible material deposition independent of downstream pressure variations [2]. However, a significant challenge arises when processing highly viscous hydrogels: the pump's internal gear mechanism cannot initially engage with the stationary material column, resulting in cavitation and inconsistent material delivery.

This work presents a novel hybrid extrusion system that combines a gerotor pump with a pneumatically actuated piston-assisted cartridge. The proposed design utilizes compressed air acting on a piston within the material cartridge to generate a defined pre-pressure, ensuring that the viscous bioink is continuously fed into the pump inlet. This pre-pressurization overcomes the initial material engagement problem and maintains consistent pump priming throughout the printing process.

Experimental results demonstrate the effect of pneumatic pre-pressurization on flow rate stability and start-up inconsistencies observed in non-assisted configurations.

The proposed system represents a promising advancement for high throughput bioprinting applications, enabling the processing of highly viscous bioinks with improved precision and repeatability. Future work will focus on optimizing pressure control algorithms and expanding material compatibility.

Author's Statement

Conflict of interest: Authors state no conflict of interest. Informed consent: Not applicable. Ethical approval: Not applicable. Acknowledgments: The authors thank the technical staff of Fraunhofer IMTE for their support. Research funding: This work was funded by EU (EFRE) and the State Schleswig-Holstein (Project: IMTE 2 - LPW21-L/2.2/262, 125 24 009).

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DOI: 10.18416/AMMM.2026.26062766