Proc. of the 9th Intl. Conf. of Asian Society for Precision Engg. and Nanotechnology (ASPEN 2022)
15–18 November 2022, Singapore. Edited by Nai Mui Ling Sharon and A. Senthil Kumar
doi://10.3850/978-981-18-6021-8_OR-01-0237

Enhancement of printing resolution and scalability using a flexible support platform Fused Deposition Modeling (FDM)

Seungjae Lee[1], Namhun Kim[1,#]

1 Department of Mechanical Engineering, Ulsan National Institute of Science and Technology, Ulsan, South Korea
Corresponding Author Email: nhkim@unist.ac.kr, TEL: +82-52-217-2715, FAX: +82-52-217-2439

KEYWORDS: Additive Manufacturing, Support structure, Flexible platform, Fused Deposition Modeling

In FDM process, additional structures of support materials to ensure structural stability and manufacturability are required when printing models with overhang feature. The support structures are generally considered as a physical constraint limiting the production efficiency, resulting the increments of the overall printing time and material usage. In this research, a novel concept of Split-bed Platform is proposed, which can save the process time and material uses by minimizing support structures in FDM. The presented platform consists of multiple pins that can be controlled individually to fill the gap between platform and the actual printing model, reducing the heights of required support structures. The proposed support platform was designed by adopting a mechanism that controls the multiple pins with minimum number of stepper motors. The mechanism works based on shafts, that are synchronized with the printer's z-axis stepper motor and connected to each pin to transfer the movement of the motor, locking the pins at desired position. It is also able to be incorporated in a commercial FDM machine and experiments are conducted by printing modified model files. The comparison with previous platform showed that the proposed method is superior in economic and operational perspectives when compared with similar platforms.

1. Introduction

Support structures created to support objects in the additive manufacturing process consume a variety of resources, such as increased process time, removal work, additional materials, and larger data files, which are maximized as the size of the model increases. To achieve the purpose of shortening the processing time and reducing material costs, research about reducing support structures has been variously studied. One of the representative methods is a 5-axis 3d printer which enables rotation of the nozzle and bed platform by adding two more axes to the existing 3-axis (x, y, z), eliminating the need for support structures. However, due to the need for the complex mechanical structure and control system, it still needs further studies to be applied to be put into practical use.

Therefore, a new method is proposed which reduce the support structures by replacing certain part of support structures with a set of dynamically controlled pins as a bed platform that does not have a complex structure and can be operated using traditional methods. Shen et al. [1] presented “Flexible support platform” where each pin is synchronized with an individual linear stepper motor, enabling the up and down driving individually. Xu et al. [2] improved this method by proposing “Reusable Support” which is combined with metal tubes, magnetic discs, and magnetic rings to enable individual pin lift with a single stepper motor.

In this research, we propose an independent mechanism called “Split-bed platform” to solve the above problem while keeping the automaticity. The concept design of the platform and comparison with previous methods are presented in Section 2. The conclusion with a future plan is set out in Section 3.

2. Split-bed platform

2.1 Concept design

To prevent the crash between the platform and the nozzle during printing, which means the platform should not affect the toolpath of the nozzle, it is necessary to maintain a continuous plane from the nozzle position by driving the pin corresponding to the part where the support structure is needed by the thickness of layer after stacking one layer. The Fig. 1 shows the diagram of the platform’s driving method.

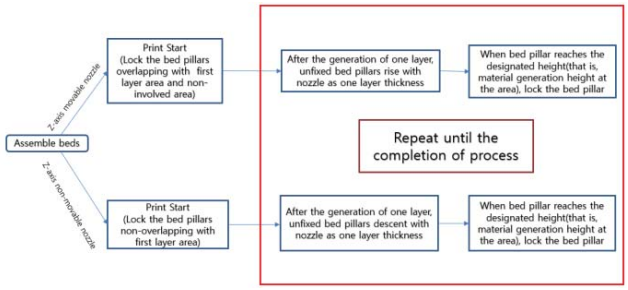
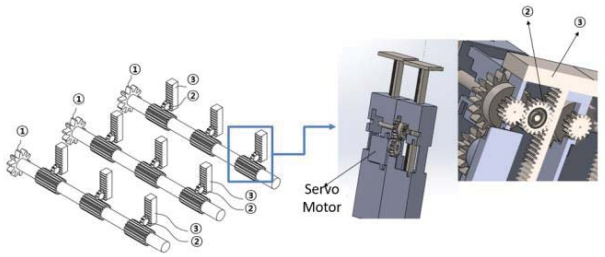


Fig. 1 Diagram of Split-bed platform's driving method

To implement the above method with a small number of stepper motors, we designed the structure design of the apparatus as shown in Fig. 2. While a stepper motor synchronized with the printer's Z-axis motor rotates multiple horizontal axes, the break-gear which location is decided by a servo motor and is always attached to the horizontal axis decides whether to deliver the rotation of axis to the pin or not by switching the location. Three different models will be printed in both the original FDM 3D printer and the mock-up platform consisting of 4x4 pins to compare printing time and support structure's weight.



① : Horizontal axis connected with a stepper motor
② : Break gear
③ : Pin

Fig. 2 Structure diagram of Split-bed platform

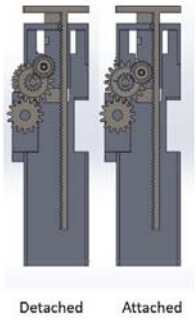


Fig. 3 Position of break gear controlled by servo motor

2.2 Comparison with previous research

The two previous studies which are mentioned above have their own pros and cons. In the flexible support platform, since the size of the pin must be larger than the stepper motor, it is difficult to improve the resolution of the platform. Also, when it comes to the extension of the platform, it has disadvantages in terms of economics and scalability due to the additional purchase of motors. The reusable support tried to solve these problems by deviating from the restrictions of size reduction and enabling the platform's single motor drive. However, the user must install tubes and magnetic discs on each pin manually which will decide the driving range of the pin before the printing process. These tasks will become more complex as the platform expands. Though the split-bed platform does not completely deviate from the size limit as much as the reusable support does due to the presence of a servo motor, it does not require any set of manual settings since the drive range of the individual pin will be designated by a control system. Also, when it comes to the platform's expansion, it only needs additional servo motors for each pin which are relatively cheaper than the stepper motors.

3. Conclusions

In this research, a novel concept of the Split-bed platform is presented. It can replace the certain partition of existing support structures with multiple pins by deciding the drive range through the location of break gear between the pin and horizontal axis. Therefore, by successfully reducing the generation of the support structure, the platform achieved the reduction of process time and material consumption while having an advantage in terms of scalability compared to previous research.

When it comes to the big area additive manufacturing (BAAM), which prints large areas by the extrusion method, it is difficult to generate support structure due to the weight of the stacked material and therefore, results in many limitations of model design. We will be discussing about the installation of the platform in this area which is likely to result the reduction of materials in tone units for future work.

REFERENCES

1. Hongyao, S., Xiaoxiang, Y. & Jianzhong, F. Research on the flexible support platform for fused deposition modeling. Int J Adv Manuf Technol 97, 3205–3221 (2018).
2. Yang Xu, Ziqi Wang, Siyu Gong, Yong Chen, Reusable support for additive manufacturing, Additive Manufacturing, Volume 39, 2021, 101840, ISSN 2214-8604