A Pegboard-based Side-mounted Desk Organizer Fabricated *via* Fused Deposition Modeling

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To address the issue of insufficient desktop space in modern office and home environments, this study developed a side-mounted desktop organizer based on a pegboard. Comparative experiments on printing accuracy and mechanical performance were conducted using three commonly used 3D printing filaments in the market: polylactic acid (PLA), polyethylene terephthalate glycol (PETG), and acrylonitrile-butadiene-styrene (ABS). The results showed that among the X, Y, and Z directions, PLA specimens exhibited the smallest dimensional errors, PETG showed intermediate values, and ABS displayed the largest. In terms of tensile strength and elastic modulus, PLA specimens demonstrated the highest values, PETG ranked second, and ABS had the lowest. Therefore, PLA filament was selected as the printing material for the desktop organizer, and fused deposition modeling (FDM) technology was used to complete the 3D printing of the prototype. The 3D-printed desktop organizer features good surface quality and high assembly accuracy, effectively expanding the vertical storage space of the desk and enabling organized storage of small items, such as stationery and cables, demonstrating strong potential for application and promotion.

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Keywords: 3D printing; FDM technology; PLA filaments; Desk organizer; Pegboard

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INTRODUCTION

With the continuous increase in the number of personal electronic devices, panel desks in modern office and home environments are facing increased spatial pressure. Laptops, desk lamps, stationery, mobile devices, and charging adapters collectively crowd the limited desktop space. Research has shown that a reduction in available desktop surface area significantly increases users' action interruption frequency and cognitive load, thereby reducing work efficiency (Chen *et al.* 2022). When replacing the desk with a larger one is not feasible, expanding storage space in the vertical direction becomes an effective alternative strategy. Because the side areas of the desk are typically underutilized, neither interfering with desktop operations nor compromising visibility and accessibility, they are well-suited for transformation into storage spaces (Hu *et al.* 2024). Therefore, this study designs a side-mounted desktop organizer for panel desks, enabling the organized storage of miscellaneous items, such as stationery and cables, without damaging the desk structure, and demonstrating clear ergonomic value and application prospects (Huang *et al.* 2022).

As a connection device characterized by regularly distributed circular holes, pegboards offer the advantages of simple structure, expandability, and high compatibility.

They have been widely used in areas such as tool storage and product display. Users can freely install various accessories, such as hooks, shelves, and containers, into the holes of the pegboard as needed, enabling flexible configuration and dynamic adjustment of the storage space (Wang *et al.* 2022). However, traditional pegboards and their storage accessories largely rely on metal stamping or injection molding processes, which suffer from high mold costs, long development cycles, and difficulty supporting small-batch customization. These limitations hinder their adoption in personalized office and home scenarios.

To achieve the rapid manufacturing of the pegboard-based side-mounted desk organizer, this study selected fused deposition modeling (FDM) technology as the processing method. FDM is one of the most widely adopted technologies in the field of 3D printing (Feng *et al.* 2022). Its principle involves heating thermoplastic filaments to a molten state through a nozzle, which are then extruded and deposited layer by layer onto a printing platform along a preset path. The molten material solidifies upon cooling, ultimately building up the prototype part (Wang *et al.* 2019). This technology offers advantages, such as low equipment cost, a wide variety of available materials, and no need for complex post-processing, making it one of the mainstream technologies for desktop-level 3D printing (Yang *et al.* 2022). More importantly, FDM enables the one-time printing of prototype parts with complex geometries and connection structures without the need for molds, thereby significantly improving design freedom and development efficiency. It provides a new technological pathway for the rapid and efficient manufacturing of pegboards and their accessories (Zhang *et al.* 2023).

The FDM technology offers a wide variety of printable filaments. Among them, the three most commonly used filaments are polylactic acid (PLA), polyethylene terephthalate glycol (PETG), and acrylonitrile-butadiene-styrene (ABS). To identify the most suitable filament for 3D printing the side-mounted desk organizer, this study conducted comparative experiments on PLA, PETG, and ABS filaments. Considering that pegboards and their storage accessories have high requirements for assembly accuracy and mechanical performance, printing accuracy and tensile performance were selected as evaluation indicators. Based on the optimal filament identified through the comparative experiments, this study applied FDM technology to fabricate the side-mounted desk organizer. The 3D-printed desk organizer exhibited good assembly accuracy and mechanical performance, demonstrating strong potential for practical application.

With the continuous development of 3D printing materials, cellulose and its derivatives are being used in 3D printing filaments for the improvement or enhancement of the performance of printed products. In this study, the authors successfully fabricated a side-mounted desktop organizer using PLA filament via FDM technology, preliminarily verifying the feasibility of the structural design of the organizer. Based on this, the authors hope to explore, in future research, the possibility of partially replacing PLA filament with cellulose and its derivative composite filaments, so as to further improve the mechanical performance and surface quality of the products while maintaining good printability.

EXPERIMENTAL

Materials

In this study, three types of 3D printing filaments commonly available on the market (PLA, PETG, and ABS) were subjected to comparative experiments. All three

filaments were from the same brand (Miracle 3D, Suzhou, China) and had the same specifications (diameter of 1.75 mm). Among them, the PLA filament had a density of 1.20 g/cm³ and an extrusion temperature of 200 °C; the PETG filament had a density of 1.23 g/cm³ and an extrusion temperature of 220 °C; and the ABS filament had a density of 1.05 g/cm³ and an extrusion temperature of 230 °C.

Specimen Preparation

To compare the printing accuracy and tensile performance of three filaments (PLA, PETG, and ABS), corresponding specimens were designed. Cubic specimens (30 mm × 30 mm × 30 mm) were used for the printing accuracy comparison, while dumbbell-shaped specimens conforming to ASTM D638 (2022) were adopted for the tensile performance comparison. The three-dimensional models of both specimen types (as shown in Fig. 1) were designed using SolidWorks software (Dassault Systemes, Paris, France) and manufactured using an FDM 3D printer (Miracle 3D, Suzhou, China). Five cubic specimens and five dumbbell-shaped specimens were printed for each filament type. Except for the extrusion temperature settings (200 °C for PLA, 220 °C for PETG, and 230 °C for ABS), all other conventional printing parameters were kept constant, including a printing speed of 60 mm/s, infill rate of 30%, layer height of 0.2 mm, and extrusion multiplier of 100%.

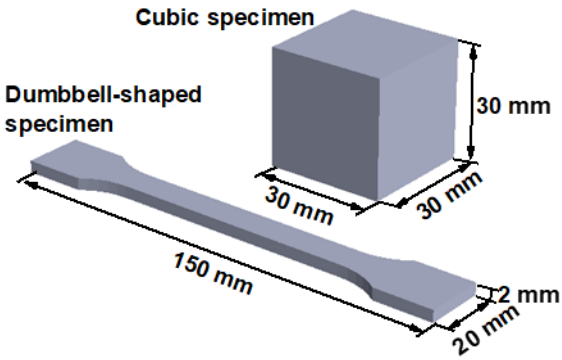


Fig. 1. Schematic diagram of cubic specimen and dumbbell-shaped specimen

Performance Test

Dimensional errors of the cubic specimens fabricated from the three filaments (PLA, PETG, and ABS) were measured and calculated in the X, Y, and Z directions using a Vernier caliper (Delixi, Leqing, China). The specific method involved subtracting the design dimension from the actual measured dimension in each direction and then dividing the result by the design dimension to obtain the dimensional error in that direction.

Tensile performance of the dumbbell-shaped specimens prepared from the three filaments were tested using a universal mechanical testing machine (AG-X, Shimadzu, Kyoto, Japan) in accordance with the tensile test method specified in the ASTM D638 (2022) standard. The tests were conducted under quasi-static loading conditions at a loading speed of 1 mm/min and a room temperature of 20 °C. The two most representative indices from the tensile tests, namely tensile strength and elastic modulus, were selected as evaluation metrics.

RESULTS AND DISCUSSION

Comparison of Printing Accuracy

Dimensional error measurements were conducted on cubic specimens fabricated from PLA, PETG, and ABS filaments, and the averaged results are presented in Fig. 2. As shown in Fig. 2, the PLA specimens exhibited the highest printing accuracy, with dimensional errors of –0.62%, –0.65%, and –0.56% in the X, Y, and Z directions, respectively. This performance is primarily attributed to the low glass transition temperature (T_g) of PLA (approximately 60 °C), which determines the temperature range over which the polymer transitions from a rubbery to a glassy state (Meng *et al.* 2025). The low T_g implies that, during cooling from the extrusion nozzle to room temperature, PLA remains in a relatively soft rubbery state over a wide temperature range. In this state, the molecular chains possess high mobility, allowing them to freely rearrange and release internal thermal stresses, thereby significantly reducing warping and shrinkage deformations caused by uneven cooling (Wang *et al.* 2023). In contrast, the ABS specimens demonstrated the lowest printing accuracy, with dimensional errors of –0.94%, –0.96%, and –0.78% in the X, Y, and Z directions, respectively. This is because ABS has a higher glass transition temperature, entering the rigid glassy state at a higher temperature (approximately 105 °C), where the molecular chains are frozen. The internal stresses generated by cooling shrinkage cannot be promptly relaxed, leading to interlayer stress accumulation and inducing warping and shrinkage deformations. The printing accuracy of the PETG specimens fell between those of PLA and ABS, with dimensional errors of –0.68%, –0.67%, and –0.59% in the X, Y, and Z directions, respectively. This is attributable to the glass transition temperature of PETG (approximately 80 °C), which lies between those of PLA and ABS. During cooling, PETG exhibits an intermediate stress relaxation time, and thus its thermal shrinkage degree is between those of the other two materials (PLA and ABS). In summary, under conventional printing conditions, PLA exhibits the highest printing accuracy, followed by PETG, while ABS performs the worst.

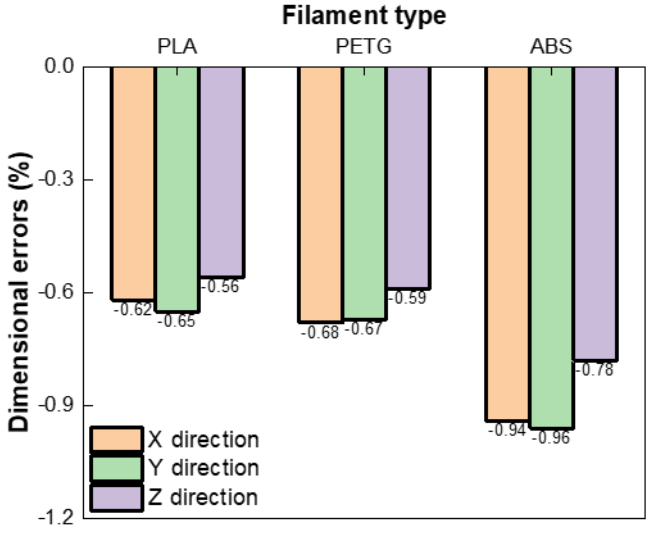


Fig. 2. Comparison of printing accuracy

Comparison of Mechanical Performance

Tensile strength and elastic modulus tests were conducted on dumbbell-shaped specimens fabricated from PLA, PETG, and ABS filaments, and the averaged results are presented in Fig. 3. As shown in Fig. 3, the PLA specimens exhibited the highest tensile strength and elastic modulus, reaching 48.13 MPa and 2.81 GPa, respectively. PLA is a semi-crystalline polymer. Although its crystallinity is typically below 10% due to rapid cooling during the fused deposition modeling process, the small crystalline regions can still act as physical crosslinking points, effectively restricting the motion of molecular chains in the amorphous regions. This enhances the resistance of PLA specimens to fracture and deformation, endowing them with high strength and stiffness. In contrast, the ABS specimens exhibited the lowest tensile strength and elastic modulus, at 37.36 MPa and 2.12 GPa, respectively. This is because ABS is an amorphous polymer, whose molecular chains remain in a completely disordered entangled state after cooling, lacking the rigid skeletal support provided by crystalline regions. Under tensile loading, the molecular chains of ABS are more prone to slippage and fracture, resulting in lower strength and stiffness. The PETG specimens exhibited tensile strength and elastic modulus of 42.4 MPa and 2.34 GPa, respectively, falling between those of PLA and ABS. Although PETG is also an amorphous polymer, the incorporation of cyclohexanedimethanol comonomers into its molecular chains enhances chain segment rigidity, providing greater structural stability in the amorphous state compared to ABS. However, because the PETG matrix lacks the crystalline reinforcement effect present in PLA, its overall mechanical performance is lower than that of PLA specimens. In summary, under conventional printing conditions, PLA exhibits the best mechanical performance, followed by PETG, while ABS performs the worst.

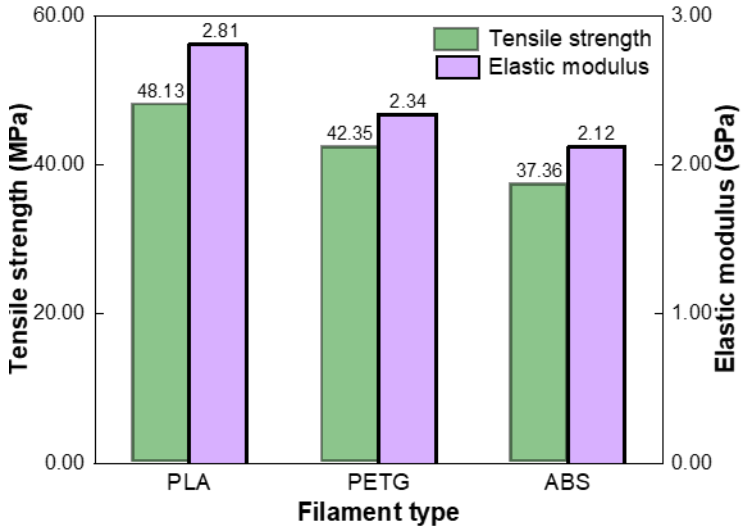


Fig. 3. Comparison of mechanical performance

3D PRINTING PRACTICE

Three-dimensional Model Design

The side-mounted desktop organizer based on a pegboard adopts a modular design philosophy, aiming to achieve flexible configuration and dynamic adjustment of storage

space (Li *et al.* 2023). Three-dimensional modeling of the desktop organizer (as shown in Fig. 4) was completed using SolidWorks software. The main design contents include the following three aspects: (1) Design of the clamping device: By measuring the thickness of common panel desktops, a threaded clamping device adaptable to desktop thicknesses ranging from 15 to 35 mm was designed, ensuring that the desktop organizer can be stably installed on the edges of desktops with different specifications (Mo *et al.* 2022). (2) Design of the pegboard: In the main structure of the desktop organizer, a pegboard characterized by uniformly distributed elliptical holes was designed, providing a standardized interface for the free combination and positional adjustment of various storage accessories. (3) Design of multifunctional storage accessories: To meet the storage needs of common desktop items, a variety of practical accessories were developed, including a pen holder for stationery and cable clips for fixing cable routing.

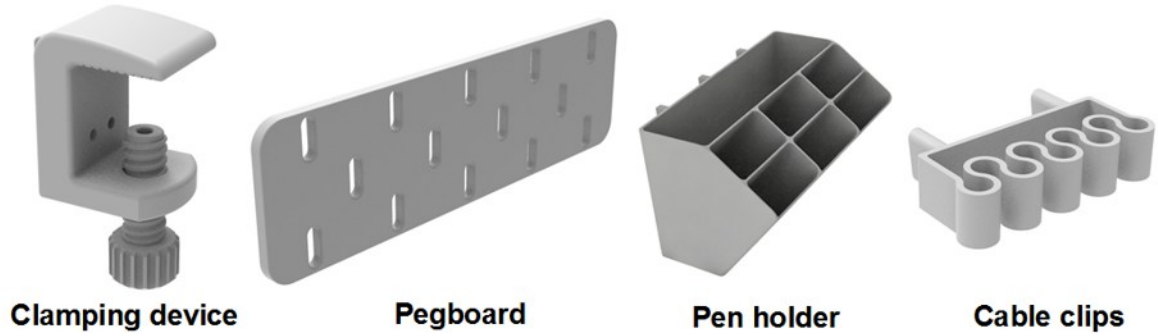


Fig. 4. Three-dimensional modeling of the desktop organizer

Prototype Manufacturing

Based on FDM technology, PLA filament was used for the 3D printing of the side-mounted desktop organizer. Regarding the printing parameters, according to the recommended process parameters provided by the filament manufacturer, the layer height was set to 0.2 mm, the extrusion multiplier to 100%, the printing speed to 60 mm/s, the printing temperature to 200 °C, the retraction distance to 5 mm, the infill density to 30%, the infill pattern to grid, and the bed temperature to 50 °C.

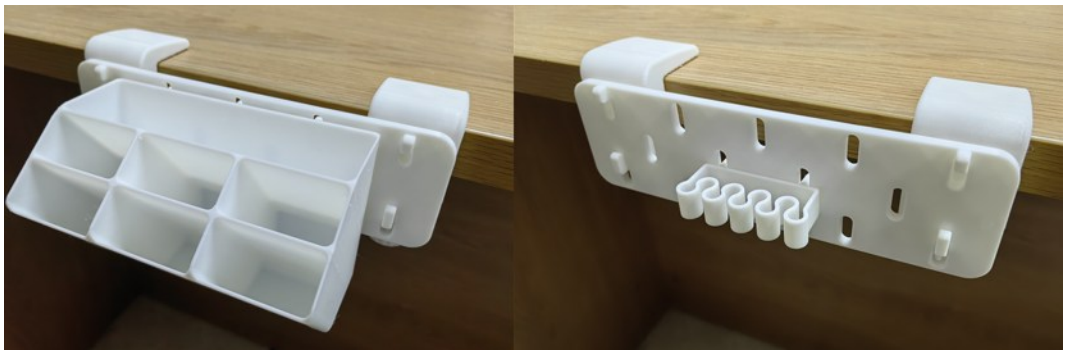


Fig. 5. The 3D-printed prototype and the installation view

The 3D-printed prototype and the installation view are shown in Fig. 5. The desktop organizer exhibited high surface quality and assembly accuracy, as shown in the figure. It is capable of expanding the storage space of the desk in the vertical direction, enabling

orderly storage of miscellaneous items such as stationery and cables. Moreover, due to the introduction of the pegboard, users can freely install different storage accessories onto the holes of the pegboard according to actual needs, thereby achieving flexible configuration and dynamic adjustment of the storage space. This design possesses high potential for application and promotion.

CONCLUSIONS

1. To address the issue of insufficient desk space in modern office and home environments, this study developed a side-mounted desktop organizer based on a pegboard. Comparative experiments were conducted to evaluate the printing accuracy and mechanical performance of three filaments: poly(lactic acid) (PLA), poly(ethyleneterephthalate glycol) (PETG), and poly(acrylonitrile butadiene styrene) (ABS). The results showed that, in the X, Y, and Z directions, PLA specimens exhibited the smallest dimensional errors, followed by PETG, while ABS specimens showed the largest errors. Regarding tensile strength and elastic modulus, PLA demonstrated the highest performance, followed by PETG, with ABS exhibiting the lowest values.
2. PLA filament was selected as the printing material for the desktop organizer, and fused deposition modeling (FDM) technology was used to complete the 3D printing of the prototype. The 3D-printed desktop organizer features good surface quality and high assembly accuracy, effectively expanding the vertical storage space of the desk and enabling organized storage of small items, such as stationery and cables, demonstrating strong potential for application and promotion.

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